Service Guide

Agilent E5270A 8 Slot Parametric Measurement Mainframe

Agilent E5272A/E5273A 2 Channel Source Monitor Unit

Preliminary Edition

Agilent Part Number: E5270-90900

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Printing History

New editions are complete revisions of the manual. Update packages, which are issued between editions, contain additional and replacement pages to be merged into the manual by the customer. The dates on the title page change only when a new edition is published. No information is incorporated into a reprinting unless it appears as a prior update; the edition does not change when an update is incorporated.

The software revision code printed before the date indicates the version level of the software product at the time the manual or update was issued. Many product updates and fixes do not require manual changes and, conversely, manual corrections may be done without accompanying product changes. Therefore, do not expect a one to one correspondence between product updates and manual updates.

Preliminary Edition December 2002

Safety Summary

The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual may impair the protections provided by the equipment. In addition, it violates safety standards of design, manufacture, and intended use of the instrument. Agilent Technologies, Inc. assumes no liability for customer's failure to comply with these requirements.

GROUND THE INSTRUMENT

To minimize shock hazard, the instrument chassis and cabinet must be connected to an electrical ground. The power terminal and the power cable must meet International Electrotechnical Commission (IEC) safety standards.

DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE

Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

KEEP AWAY FROM LIVE CIRCUITS

Operation personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified maintenance personnel. Do not replace components with power cable connected. Under certain conditions, dangerous voltages may exist even with the power cable removed. To avoid injuries, always disconnect power and discharge circuits before touching them.

DO NOT SERVICE OR ADJUST ALONE

Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT

Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to a Agilent Technologies Sales and Service Office for services and repair to ensure that safety features are maintained.

DANGEROUS PROCEDURE WARNINGS

Warnings, such as in the example below, precede potentially dangerous procedures throughout this manual. Instructions contained in the warnings must be followed.

WARNING **Dangerous voltages, capable of causing death, are present in this instrument. Use extreme caution when handling, testing, and adjusting.**

Safety Symbols

The general definitions of safety symbols used on equipment or in manuals are listed below.

Instruction manual symbol: the product will be marked with this symbol when it is necessary for the user to refer to the instruction manual in order to protect against damage to the instrument.

Indicates dangerous voltage and potential for electrical shock. Do not touch terminals that have this symbol when instrument is on.

Protective conductor terminal.

It is intended for connection to an external protective conductor for protection against electric shock in case of a fault or the terminal of a protective earth electrode.

Frame or chassis terminal. A connection to the frame (chassis) of the equipment which normally includes all exposed metal structures.

Alternating current.

Direct current.

Electrical shock.

ON (Supply).

OFF (Supply).

WARNING — The warning sign denotes a hazard. It calls attention to a procedure, practice, condition or the like, which, if not correctly performed or adhered to, could result in injury or death to personnel.

CAUTION — The caution sign denotes a hazard. It calls attention to an operating procedure, practice, condition or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the product.

NOTE — The note sign denotes important information. It calls attention to a procedure, practice, condition or the like, which is essential to highlight.

Preface

Contents

WARNING **The information in this manual is provided for use by service trained personnel only. To avoid electrical shock, do not perform any procedures in this manual, unless you are qualified to do so.**

This manual contains information relating to the calibration and repair of the Agilent E5270A 8 slot parametric measurement mainframe, Agilent E5272A 2 channel (medium power, medium power) source/monitor unit, and Agilent E5273A 2 channel (high power, medium power) source/monitor unit. The manual consists of the following chapters:

Chapter 1 , “Overview” provides an overview, product configurations, products and options, accessories, and service tools for the E5270A, E5272A, and E5273A.

Chapter 2 , “Calibration” contains the information and instructions for the performance verification and ADC/SMU calibrations.

Chapter 3 , “Troubleshooting” contains the information and instructions for the troubleshooting.

Chapter 4 , “Replacement Procedure” contains the assembly removal procedures and installation procedures.

Chapter 5 , “Replaceable Parts” contains the replaceable parts and assembly location information.

Chapter 6 , “Theory of Operation” contains the theory of operation to aid in the troubleshooting.

Appendix A , “Error Message,” contains meanings of the error codes.

Other Manuals

See the following user's manuals for more detailed information on the above topics, user operation, and programming.

User's Guide (Agilent part number E5270-90000)

Programming Guide (Agilent part number E5270-90010)

The following manuals contain service information for the Agilent 16440A, Agilent 16441A, and Agilent 16442A.

Agilent 16440A SMU/Pulse Generator Selector User's Guide (Agilent part number 16440-90000)

Agilent 16441A R-Box User's Guide (Agilent part number 16441-90000)

Agilent 16442A Test Fixture User's Guide (Agilent part number 16442-90000)

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1 Overview

Product Overview

This section provides product overview for the mainframe, accessories, and calibration tool kit.

Mainframe

The Agilent E5270 series are electronic instruments for applying dc voltage or current, and measuring dc current or voltage. The Agilent E5270 series provides the following products:

- Agilent E5270A 8 slot parametric measurement mainframe

  The E5270A is the mainframe for parametric measurement modules, and consists of ground unit (GNDU) and 8 empty slots to install the source/monitor unit (SMU) modules. The LCD and front panel keys are also provided to control the modules.

  The E5270A is installable up to eight medium power SMUs (MPSMUs), up to four high-power SMUs (HPSMUs), or any physically allowable combination thereof.

- Agilent E5272A 2 channel source/monitor unit (SMU)

  The E5272A is fixed-configuration dual SMU instrument, and consists of GNDU and two MPSMUs. The LCD and front panel keys are also provided to control the modules.

- Agilent E5273A 2 channel source/monitor unit (SMU)

  The E5273A is fixed-configuration dual SMU instrument, and consists of GNDU, an HPSMU, and an MPSMU. The LCD and front panel keys are also provided to control the modules.

- Agilent E5280A high power source/monitor unit (HPSMU) module

  The E5280A is the HPSMU module for the E5270A, and occupies 2 slots. The E5280A can force and measure maximum 1 A/200 V.

- Agilent E5281A medium power source/monitor unit module

  The E5281A is the MPSMU module for the E5270A, and occupies 1 slot. The E5281A can force and measure maximum 200 mA/100 V.

Figure 1-1 Agilent E5270A/E5272A/E5273A

Agilent E5270A

Agilent E5272A/E5273A

Accessories

- test fixture

  Agilent 16442B is the test fixture for the E5270 series. You can mount a device under test (DUT) on the 16442B, and measure the device characteristics.

- cables and adapters

  Agilent 16435A, Agilent 16493J/K/L, Agilent 16494A/B, and Agilent N1253A/B/C are cables and adapters for the E5270 series. You can connect the E5270A to other instruments, test fixture, connector plate, or prober by using these cables and adapters.

- connector plates

  Agilent 16495F/G/H/J is the connector plate for the E5270 series, and is interface of connect the E5270 series, 4155C/4156C, and E5250A to the prober or test fixture.

Calibration tool kit

Agilent E5299A is a calibration tool kit for the E5270 series, and consists of calibration software, cables, adapters, and operation guide. Since the E5270 series are used in production line, the E5299A is available for self-maintenance customers.

The E5299A will be available in May 2003.

Products and Options

Table 1-1 lists Agilent product numbers and option items for Agilent E5270 series.

Table 1-1 Mainframes and modules

Agilent product number	Option item	Description
E5270A		8 slot parametric measurement mainframe
	E5270A-050	50 Hz power line frequency
	E5270A-060	60 Hz power line frequency
	E5270A-400	Add E5280A HPSMU
	E5270A-410	Add E5281A MPSMU
	E5270A-A6J	ANSI Z540 compliant calibration
	E5270A-UK6	Commercial cal. certificate w/ test data
	E5270A-ABA	Manual set, English
	E5270A-ABJ	Manual set, Japanese
E5272A		2 channel source/monitor unit (MPSMU/MPSMU)
	E5272A-050	50 Hz power line frequency
	E5272A-060	60 Hz power line frequency
	E5272A-A6J	ANSI Z540 compliant calibration
	E5272A-UK6	Commercial cal. certificate w/ test data
	E5272A-ABA	Manual set, English
	E5272A-ABJ	Manual set, Japanese
E5273A		2 channel source/monitor unit (HPSMU/MPSMU)
	E5273A-050	50 Hz power line frequency
	E5273A-060	60 Hz power line frequency
	E5273A-A6J	ANSI Z540 compliant calibration
	E5273A-UK6	Commercial cal. certificate w/ test data
	E5273A-ABA	Manual set, English
	E5273A-ABJ	Manual set, Japanese
E5280A		High power source/monitor unit module
E5281A		Medium power source/monitor unit module

Available Accessories

Table 1-2 through table 1-4 list the available accessories for E5270 series.

Table 1-2 Test fixture

Agilent product number	Option item	Description
16442B		Test fixture
	16442B-010	Add 1.5 m triaxial cables, 4 ea.
	16442B-011	Add 3.0 m triaxial cables, 4 ea.
	16442B-800	Extra blank teflon board
	16442B-801	Universal socket module, 0.1 inch pitch, with 10 pins
	16442B-802	Universal socket module, 0.075 inch pitch, with 10 pins
	16442B-803	Universal socket module, 0.05 inch pitch, with 10 pins
	16442B-810	Extra pin set (for universal socket module, 10 pins.)
	16442B-811	Extra wire set (mini banana to pin plug, 6 ea.)
	16442B-812	Extra wire set (pin plug to pin plug, 6 ea.)
	16442B-813	Extra wire set (mini banana to mini clip, 6 ea.)
	16442B-814	Extra wire set (mini banana to mini banana, 6 ea.)
	16442B-821	Socket module, 4-pin TO package
	16442B-822	Socket module, 18-pin DIP package
	16442B-823	Extra socket module, 28-pin DIP package
	16442B-890	Extra accessory case

Table 1-3 Cables and adapters

Agilent product number	Option item	Description
16435A		Interlock cable adapter (E5270 type to BNC)
16493J		Interlock cable
	16493J-001	1.5 m length
	16493J-002	3.0 m length
16493K		Kelvin triaxial cable (E5270 Kelvin to E5270 Kelvin)
	16493K-001	1.5 m length
	16493K-002	3.0 m length
16493L		GNDU cable for E5270 series
	16493L-001	1.5 m length
	16493L-002	3.0 m length
16494A		Triaxial cable
	16494A-001	1.5 m length
	16494A-002	3 m length
	16494A-003	80 cm length
16494B		Kelvin triaxial cable (E5270 Kelvin to E5250 Kelvin)
	16494B-001	1.5 m length
	16494B-002	3 m length
	16494B-003	80 cm length
N1253A		Digital I/O T-cable
N1253B		Digital I/O BNC box
N1253C		GNDU to Kelvin adapter

Table 1-4 Connector plates

Agilent product number	Option item	Description
16495F		Connector plate w/ 12×triax., interlock, GNDU
	16495F-001	Bulkhead feed through connectors (female to female)
	16495F-002	Connectors to contacts for soldering
16495G		Connector plate w/ 24×triax., interlock, GNDU
	16495G-001	Bulkhead feed through connectors (female to female)
	16495G-002	Connectors to contacts for soldering
16495H		Connector plate w/ 6×triax., 6×coax., interlock, GNDU
	16495H-001	Bulkhead feed through connectors (female to female)
	16495H-002	Connectors to contacts for soldering
16495J		Connector plate w/ 8×triax., 4×coax., Interlock, GNDU
	16495J-001	Bulkhead feed through connectors (female to female)
	16495J-002	Connectors to contacts for soldering

Service Tools

Table 1-5 and table 1-6 list the required equipment for servicing the E5270A, E5272A, and E5273A.

Table 1-5 Required equipment for calibration

Agilent product/ part number	Description	Quantity
04142-61641	Triaxial cable, 1 m	1
04155-61614	Interlock cable	1
04155-61648	Mini pin plug to banana plug cable	1
04155-65041	Calibration adapter	1
04155-65042	Shorting box for calibration adapter	1
04155-65043	Interlock test adapter	1
1250-0929	BNC shorting cap	1
11058A	Banana plug to banana plug cable	2
16353A	Standard resistor set	1
3458A	Digital multimeter	1
	E5270 calibration software[a]	1
	PC with Microsoft® Windows® and GPIB interface	1

a. This is downloadable from HSTD web (http://hpyidmk.jpn.agilent.com).

Table 1-6 Required equipment for troubleshooting

Description	Quantity
Torx® screwdriver (No. 25)	1
Hex wrench (H2.5mm)	1
Nut drivers or spanners (H5.5mm, H7mm, H1/2", and H1/4")	4
Flat-tip screwdriver	1
Pozidrive screwdrivers (No 1 and No 2)	2

NOTE Equipment for the calibration is also needed for troubleshooting.

2 Calibration

This chapter gives the information about the E5270A/E5272A/E5273A calibration, and consists of the following sections:

- “Calibration Overview”
- “Getting Started”
- “Performance Verification Procedure”
- “ADC/SMU Calibration Procedure”
- “Performance Verification Theory”
- “ADC/SMU Calibration Theory”
- “Printing Test Result”

Calibration Overview

This section describes definition of calibration, calibration flow, requirements, operating conditions, and so on.

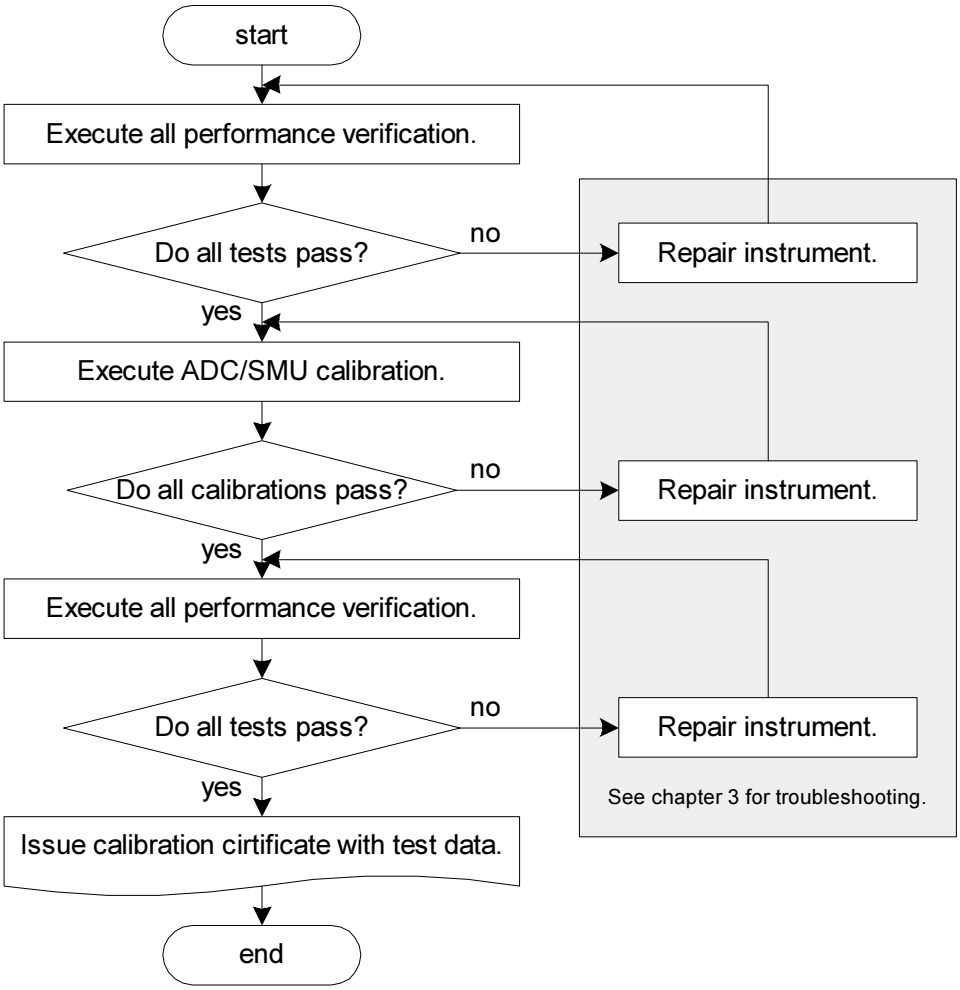
Definition of calibration

Calibration is defined as the action that confirms the equipment performance, compares it with commercial specifications, and adjusts the reference resistors and voltages values that affects the measurement and output values. The calibration consists of the performance verification and ADC/SMU calibration.

Calibration flow

You must perform the calibration as shown in figure 2-1.

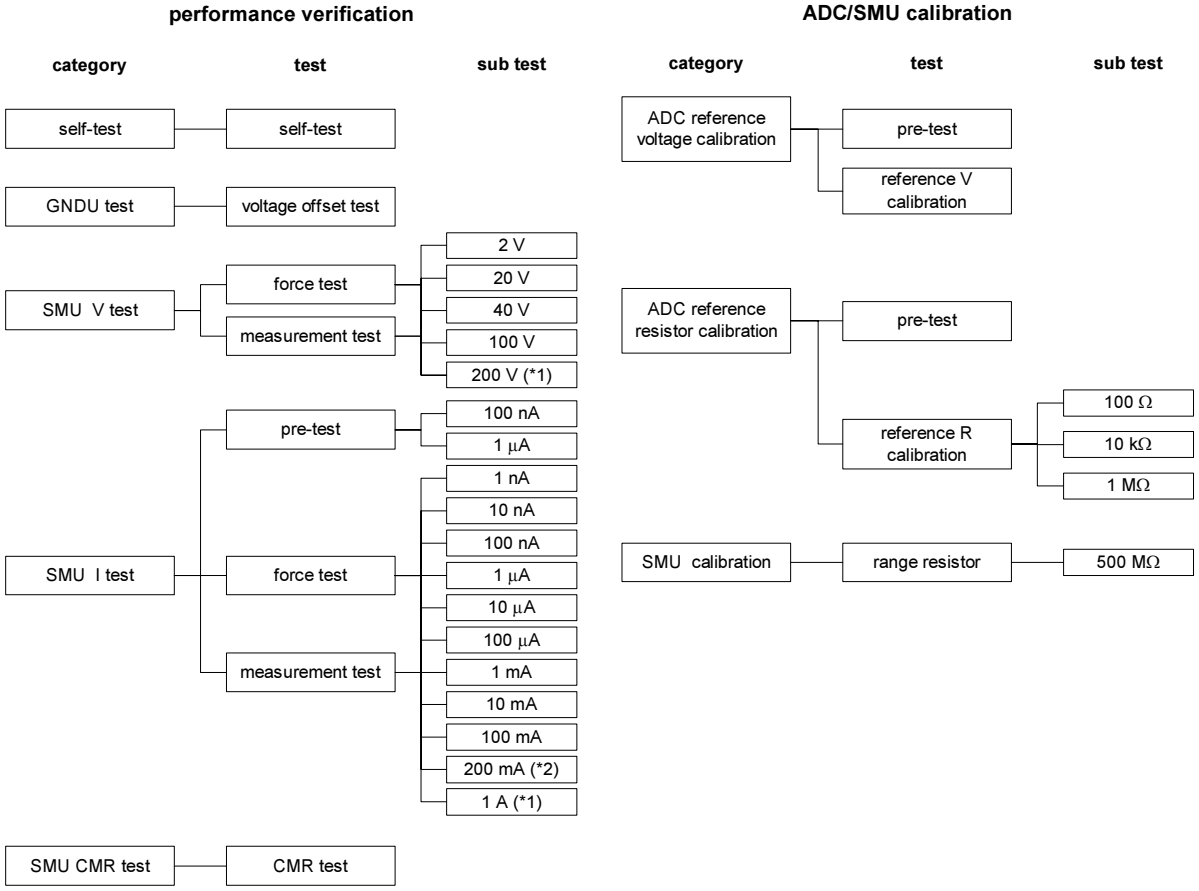
Figure 2-1 Calibration flow



Calibration structure

Figure 2-2 shows performance verification and ADC/SMU calibration structure.

Figure 2-2 Calibration structure



(*1) For HPSMU only.
(*2) For MPSMU only.

Required equipment

Table 1-5 lists the required equipment for the calibration.

NOTE Agilent 3458A and Agilent 16353A should be calibrated by an instrument traceable to the National Institute of Standards and Technologies (NIST) or an equivalent standard; or calibrated directly by an authorized calibration organization such as NIST. The calibration cycle should be in accordance with the stability specifications of each component.

NOTE The calibration software is tested under the following environment. The software will run on compatible environment, but it is not tested.

CPU	Intel® Pentium® III 550 MHz
Memory	192 Mbyte
GPIB card	Agilent 82350A
OS	Microsoft® Windows® NT 4.0
I/O library	VISA L.02.01

Operating conditions

Perform all calibration in the following conditions:

- Ambient temperature is 23 °C ± 3 °C
- Agilent E5270A series are warmed up at least 40 minutes.
- Agilent 3458A is periodically calibrated and are warmed up for four hours. Also, **ACAL** is performed after the warm-up time.
- Temperature change is within 1 °C after the **ACAL**.
- At least one SMU must be installed in the mainframe for the ADC calibration.

Calibration cycle

The E5270 series require the periodic calibration. The frequency of the calibration depends on the operating and environmental conditions under which the instrument is used. Agilent Technologies recommends that the calibration is performed at least once a year.

Also, a part of calibration should be performed when you repair a part of E5270 series that is related to the performance. The required performance verification and ADC/SMU calibration are shown in chapter 5 , “Replaceable Parts,”.

Getting Started

This section describes how to install, setup, and run the performance verification and calibration software. Perform steps 1 through 6 in this section.

NOTE Before you perform the steps 1 through 6, check if the GPIB interface card and I/O library are properly installed.

Step 1. software and hardware setup

The following is hardware and software (E5270 series calibration software) installation and set up procedure.

1. Connect GPIB cable between PC and E5270 series mainframe.
2. Turn on the PC and E5270 series mainframe.
3. Confirm that GPIB interface and driver are installed and works.
4. Install the E5270 series calibration software as follows:
   a. Download the calibration software from the HSTD web (http://hpyidmk.jpn.agilent.com).
   b. Uncompress the downloaded file.
   c. Close all running applications.
   d. Click **Start > Run**.
   e. Enter the path and setup file (ex. `C:\temp\cal\setup`), and then click **OK**.
   f. Follow the instructions on the screen to install the calibration software.
   g. Restart the computer to reconfigure the software.

   When the installation is complete, a program group is added on the **Start** menu labeled **Agilent E527x Performance Verification**.

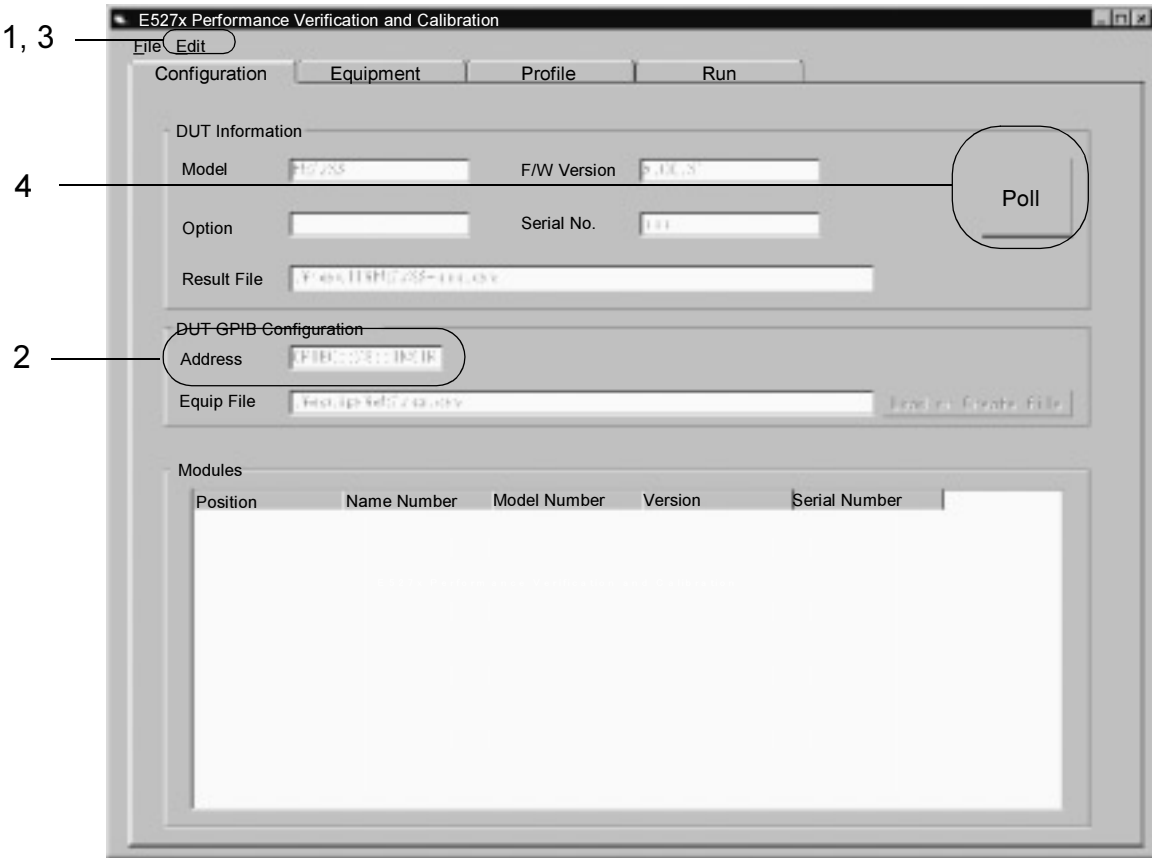
Step 2. configuring DUT information

Run the calibration software by choosing `Agilent E527x Performance Verification` on the `Start` menu. This opens the calibration software graphical user interface (GUI) as shown in figure 2-3. The calibration software is grouped into four tabs: `Configuration`, `Equipment`, `Profile`, and `Run`. The DUT configuration is done on the `Configuration` tab.

Follow these steps to configure the DUT information.

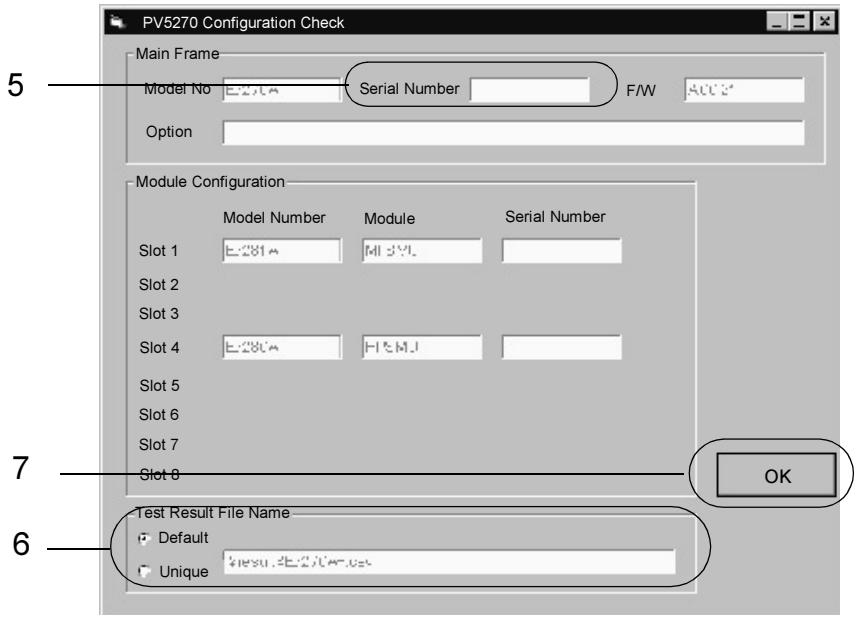
1. Click **Edit > Edit Data**. The check mark is displayed beside **Edit Data**.
2. Enter GPIB address in the blank of `DUT GPIB Configuration` area. For example, the GPIB interface name is GPIB0 and the E5270A/E5272A/E5273A GPIB address is 17, type `GPIB0::17::INSTR`.. This information is confirmable by using VISA Assistant.
3. Click **Edit > Edit Data**, and then save the configuration into the `e527xa.csv` file.

Figure 2-3 Configuration tab



4. Click **Poll**. The calibration software retrieves DUT configuration (model number, firmware revision, and module configuration), and displays them on the configuration check window as shown in figure 2-4.

Figure 2-4 PV5270 Configuration Check window



5. Enter the serial number of mainframe.
6. The default setting of the test result file name is made by serial number. If you want to change test result file name, select `Unique`, then enter the file name.

NOTE When you execute the performance verification after the ADC/SMU calibration, change the test result file name. Otherwise, previous test data cannot be extracted by test data report tool (`pvview5270.xls`).

7. Click **OK**.

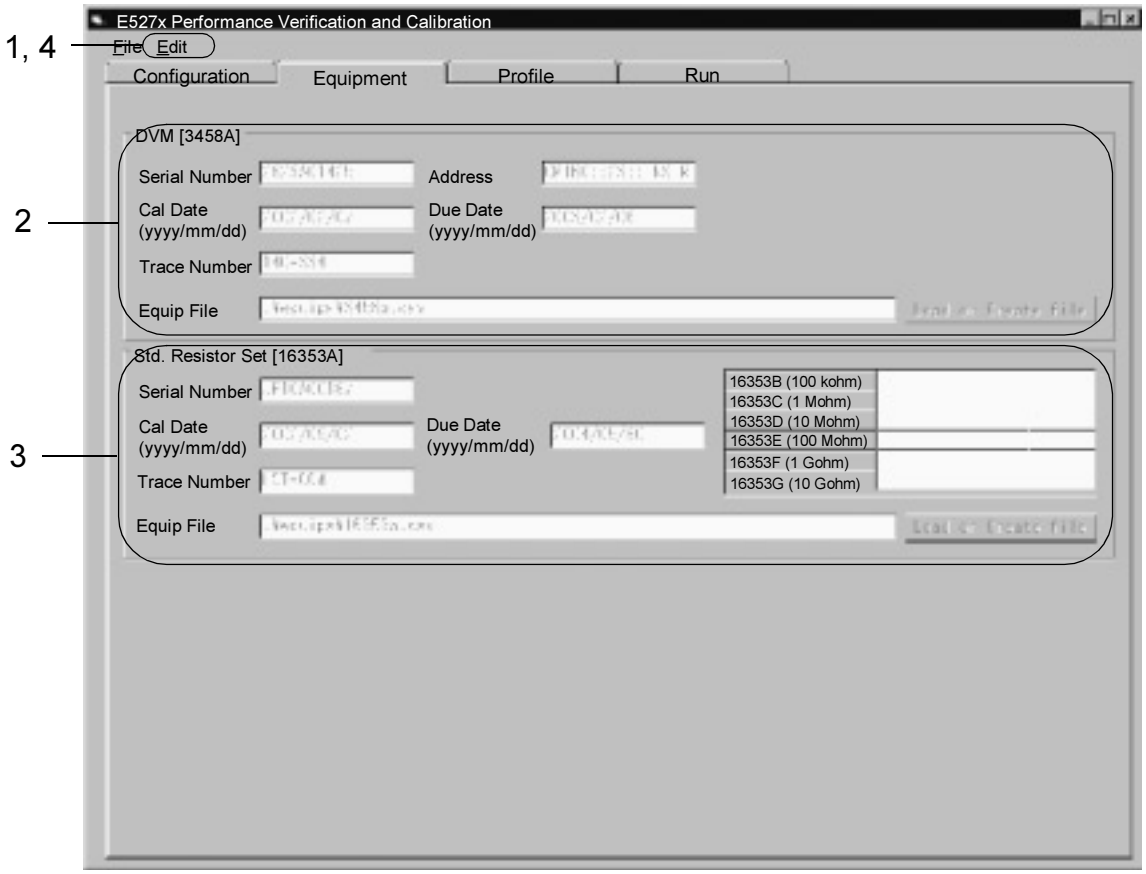
Step 3. setting calibration standards

Open the `Equipment` tab by clicking the tab, and then follow these steps to set up the calibration standards (Agilent 3458A and Agilent 16353A).

1. Click **Edit > Edit Data**. The check mark is displayed beside **Edit Data**.
2. Enter the serial number, GPIB address, calibrated date, due date, and trace number of Agilent 3458A (DMM).
3. Enter the serial number, calibrated date, due date, trace number, and resistance values of Agilent 16353A (standard resistor set).
4. Click **Edit > Edit Data**, and then save the data into the `3458a.csv` and `16353a.csv` files.

NOTE Once you enter the information and save it into the files, you can load the information by using `Load`. In default setting, the equipment setting file is made in the `C:\Program Files\Performance Verification\equips` folder, but you can put the setting files on other folder and share them with other PCs via network.

Figure 2-5 Equipment tab

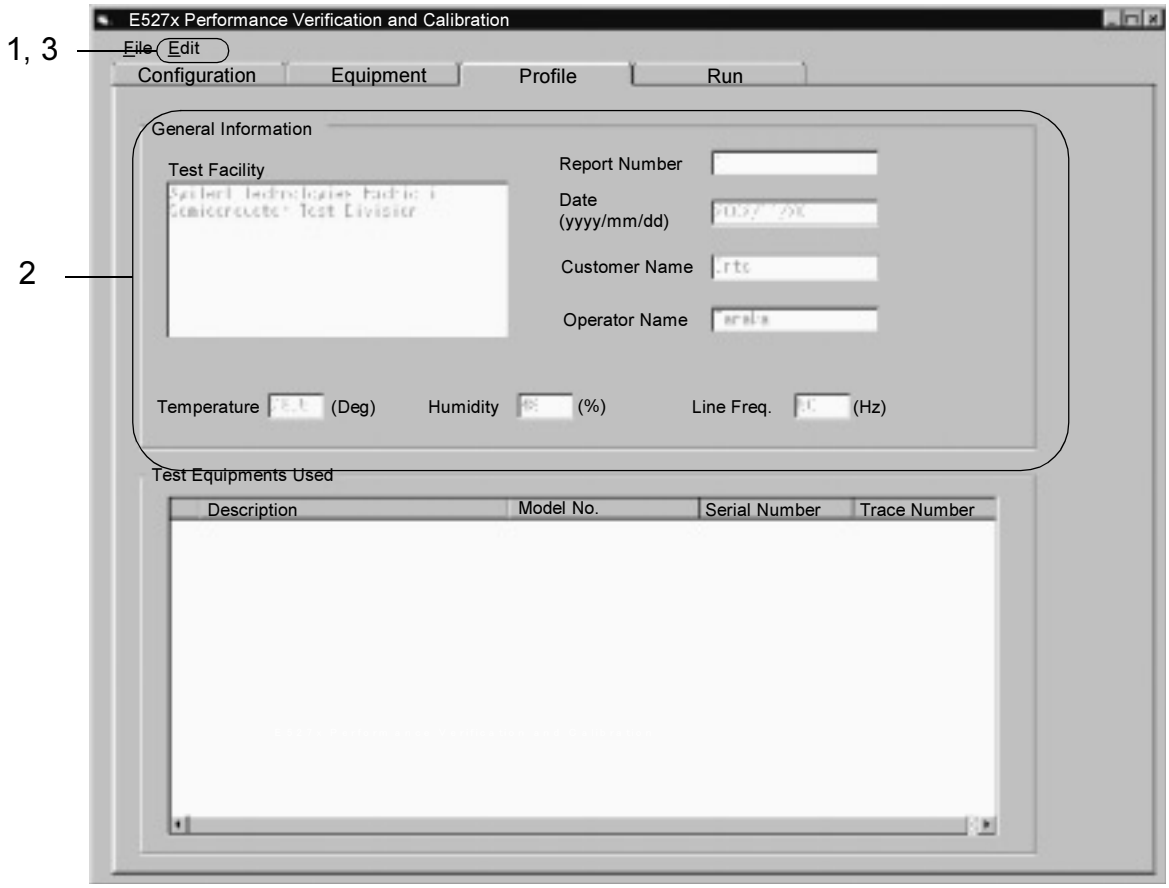


Step 4. entering operating conditions

Open `Profile` tab by clicking the tab, and then follow these steps to enter test conditions.

1. Click **Edit > Edit Data**. The check mark is displayed beside **Edit Data**.
2. Enter test facility name, report number, calibration date, customer name, operator name, temperature, humidity, and line frequency. These data are used for first page of calibration report.
3. Click **Edit > Edit Data**, and then save the data into result file specified in configuration tab.

Figure 2-6 Profile tab

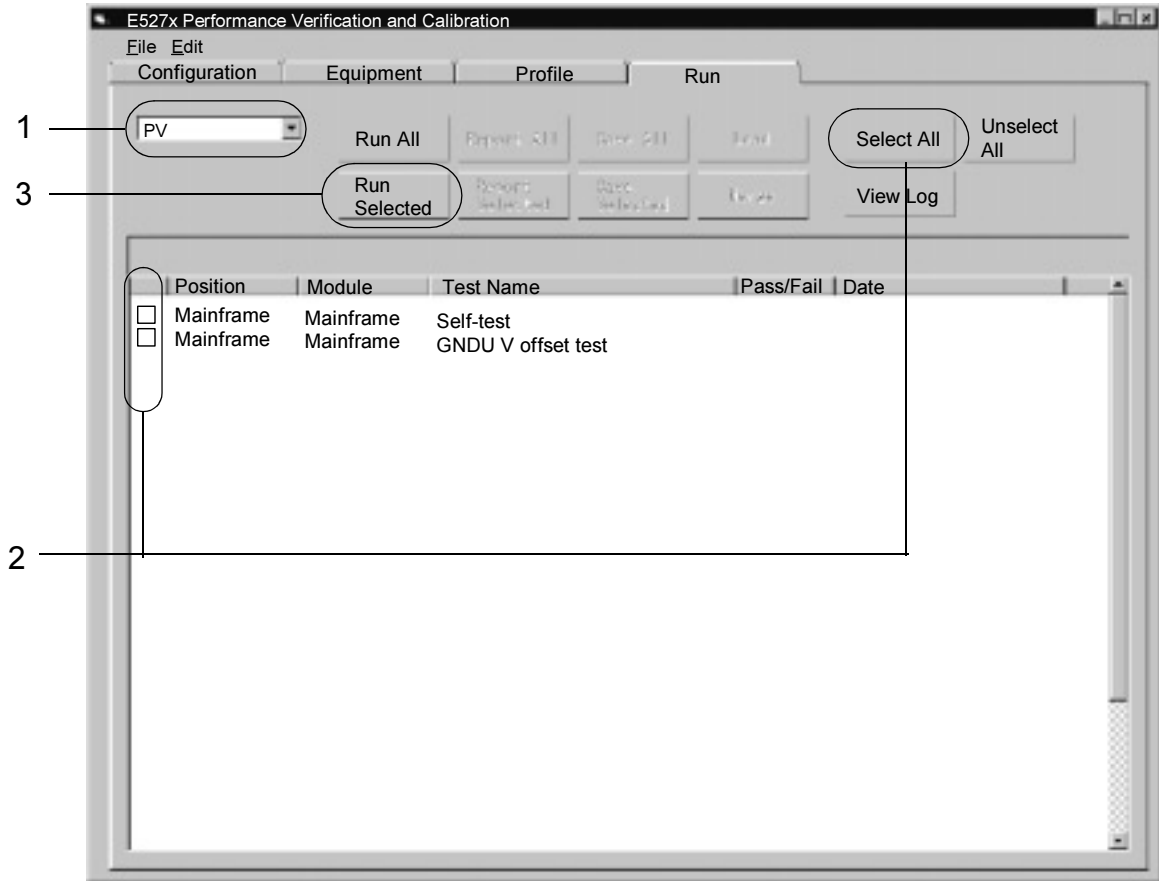


Step 5. selecting tests

Open `Run` tab by clicking the tab, and then follow these steps to execute the performance verification or ADC/SMU calibration.

1. If you want to execute the performance verification, select `PV`. If you want to execute the ADC/SMU calibration, select `Calibration`. The executable tests are displayed on the window.
2. Select tests or calibrations that you want to execute by clicking the check box or **Select All**.
3. Click **Run Selected**.

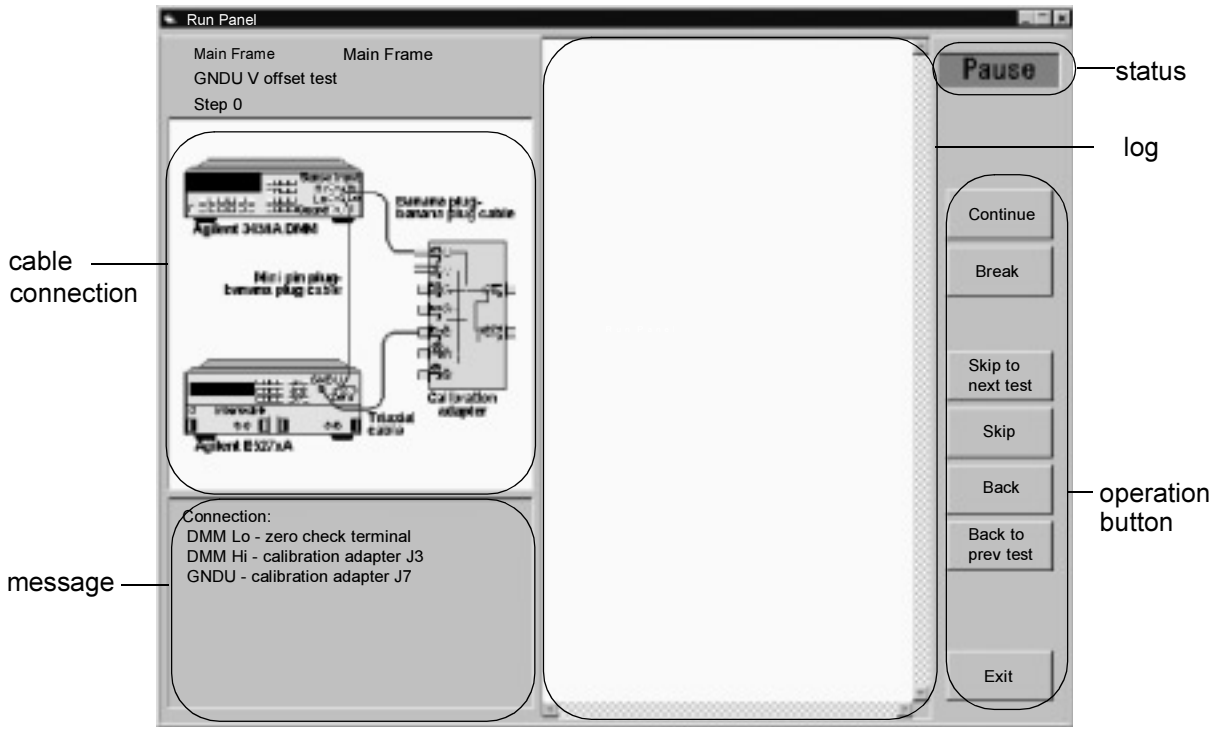
Figure 2-7 Run tab



Step 6. executing tests or calibrations

Run the selected tests or calibrations by clicking Run Selected. This opens the run panel and test introduction window as shown in figure 2-8.

Figure 2-8 Run panel



The following lists the function of the Run Panel.

Continue	Goes to next step.
Break	Stops executing tests or calibrations.
Skip to next test	Skips the current test or calibration, then goes to next.
Skip	Skips the current step, then goes to next.
Back	Returns to previous step.
Back to prev test	Returns to previous test or calibration.
Exit	Quit the performance verification or calibration, then close the Run Panel.
Cable connection	Displays the cable connection.
Message	Displays connection or test name.
Log	Displays logs for performance verification and calibration. This information is also stored in result file that you specified on `Configuration` tab.
Status	Displays the test and calibration status.

Performance Verification Procedure

This section describe the performance verification procedure, required equipment, cable connections for each tests.

Self-test

Required equipment

none

Procedure

1. Disconnect all cables and plugs from SMU. (Set SMU to "open" condition.)
2. Click **Contine**. The self-test is executed.

GNDU voltage offset test

This test verifies the ground unit (GNDU) voltage offset accuracy.

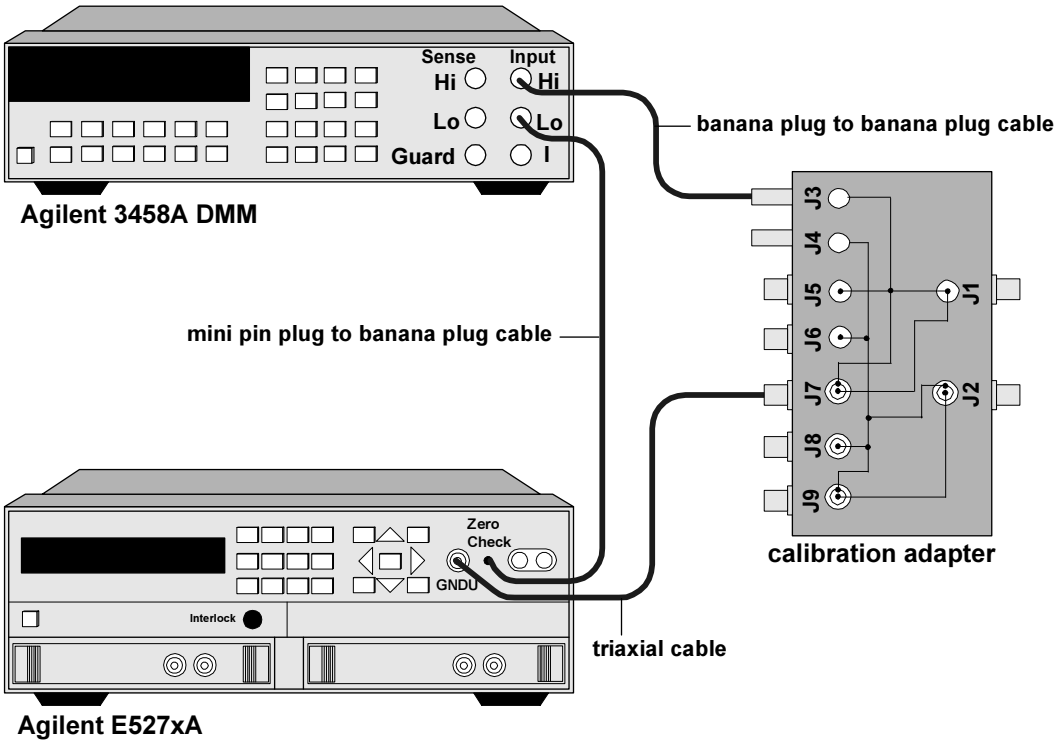
Required equipment

Triaxial cable (04142-61641)
Mini pin plug to banana plug cable (04155-61648)
Calibration adapter (04155-65041)
Banana plug to banana plug cable (Agilent 11058A)
Digital multimeter (Agilent 3458A)

Procedure

1. Connect the DMM-Lo to the zero check terminal on the mainframe front panel.
2. Connect the DMM-Hi to the calibration adapter J3.
3. Connect the GNDU to the calibration adapter J7.
4. Click **Continue**. The GNDU voltage offset test is executed.

Figure 2-9 Connection for GNDU voltage offset test



SMU voltage test

This test consists of the voltage setting test and voltage measurement test; it verifies the SMU voltage setting and measurement accuracy.

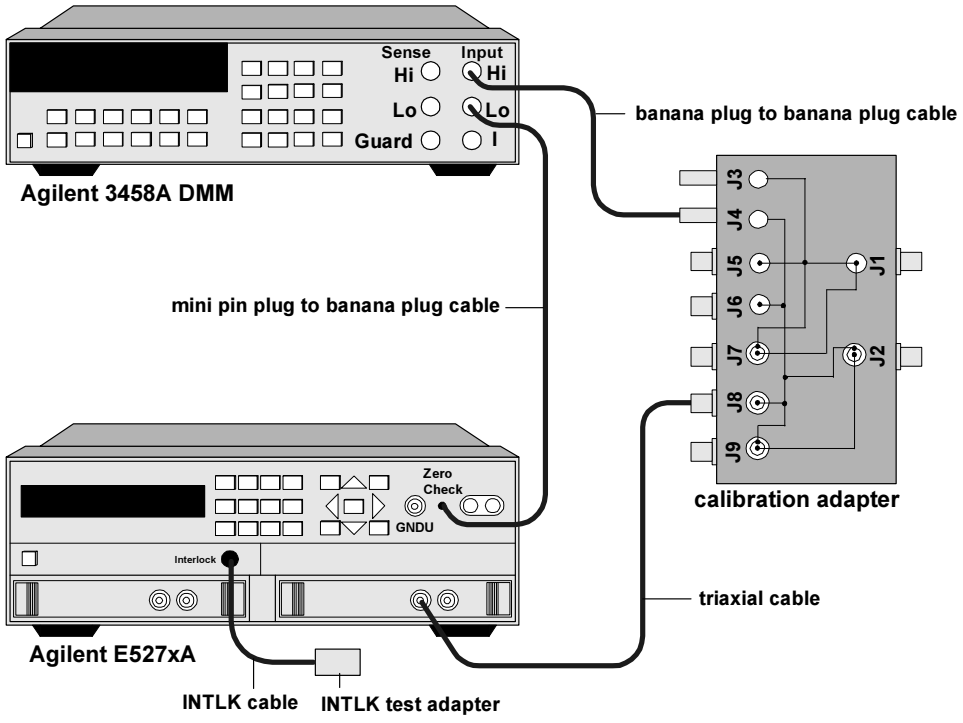
Required equipment

Triaxial cable (04142-61641)
INTLK cable (04155-61614)
Mini pin plug to banana plug cable (04155-61648)
Calibration adapter (04155-65041)
INTLK test adapter (04155-65043)
Banana plug to banana plug cable (Agilent 11058A)
Digital multimeter (Agilent 3458A)

Procedure

1. Connect the DMM-Lo to the zero check terminal on the E527xA front panel.
2. Connect the DMM-Hi to the calibration adapter J4.
3. Connect the INTLK test adapter to the Interlock terminal on the E527xA front panel with the INTLK cable.
4. Set the INTLK test adapter switch to 1 (ON).
5. Click **Continue**.
6. Connect the SMU Force to the calibration adapter J8 according to the displayed instruction.
7. Click **Continue**. The voltage setting test and voltage measurement test are executed.
8. Steps 6 and 7 are repeated until all of the selected SMUs are tested.

Figure 2-10 Connection for SMU voltage test



SMU current pre-test

This test is the pre-measurement for the SMU current test, and verifies the guard potential offset voltage.

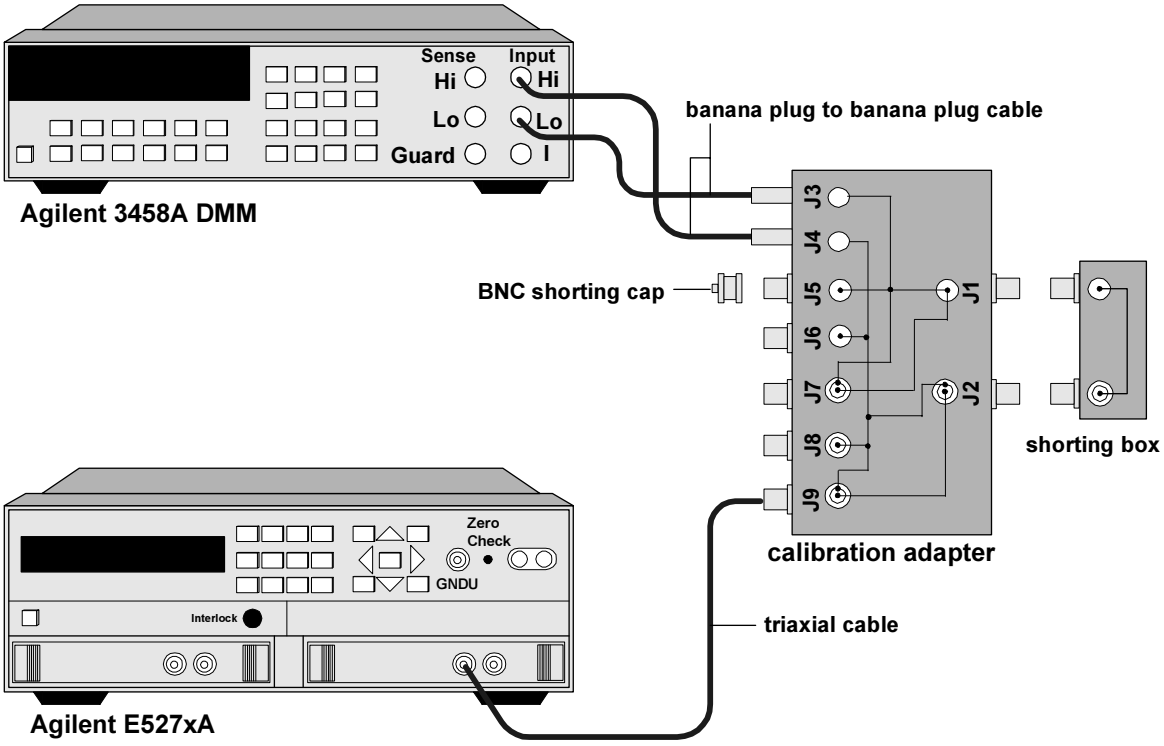
Required equipment

Triaxial cable (04142-61641)
Calibration adapter (04155-65041)
Shorting box (04155-65042)
Banana plug to banana plug cable (Agilent 11058A); 2 each
BNC shorting cap (1250-0929)
Digital multimeter (Agilent 3458A)

Procedure

1. Connect the DMM-Lo to the calibration adapter J3.
2. Connect the DMM-Hi to the calibration adapter J4.
3. Connect the BNC shorting cap to the calibration adapter J5.
4. Connect the shorting box to the calibration adapter J1 and J2.
5. Click **Continue**.
6. Connect the SMU Force to the calibration adapter J9 according to the displayed instruction.
7. Click **Continue**. The SMU current pre-test is executed.
8. Steps 6 and 7 are repeated until all SMUs are tested.

Figure 2-11 Connection for SMU current pre-test



SMU current test (for 1 nA to 10 μA ranges)

This test consists of the current setting test and current measurement test; it verifies current setting and measurement accuracy. Note that the SMU current pre-test must pass before this test.

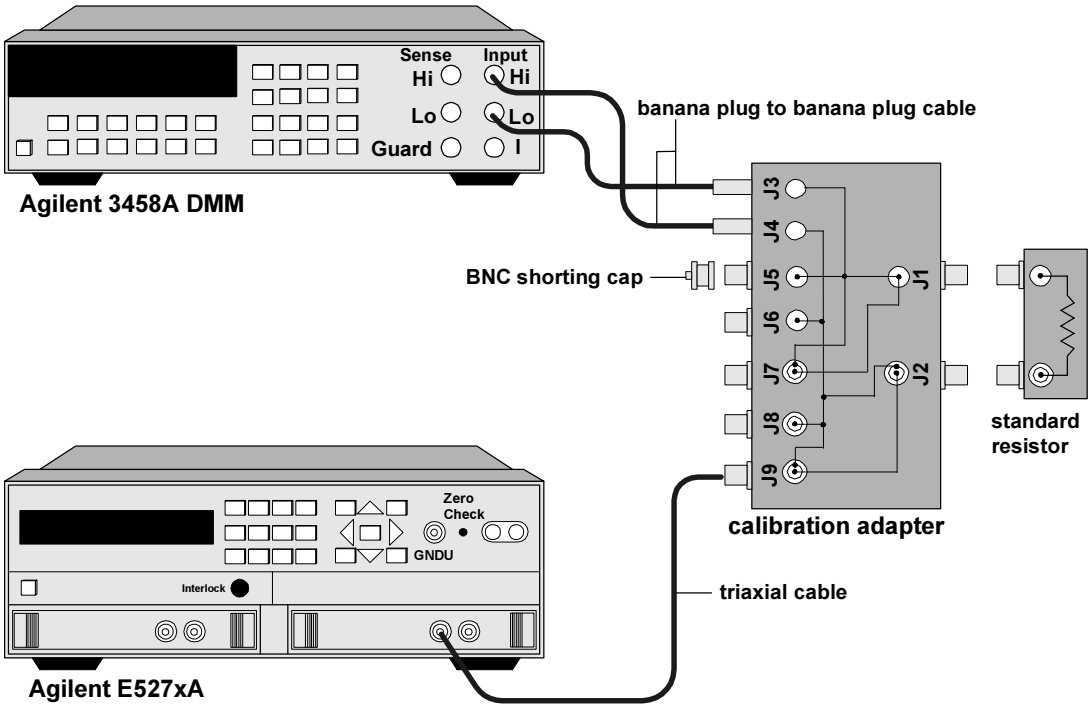
Required equipment

Triaxial cable (04142-61641)
Calibration adapter (04155-65041)
Banana plug to banana plug cable (Agilent 11058A); 2 each
BNC shorting cap (1250-0929)
Standard resistor set (Agilent 16353A)
Digital multimeter (Agilent 3458A)

Procedure

1. Connect the DMM-Lo to the calibration adapter J3.
2. Connect the DMM-Hi to the calibration adapter J4.
3. Connect the BNC shorting cap to the calibration adapter J5.
4. Connect the standard resistor to the calibration adapter J1 and J2 according to the displayed instruction.
5. Click **Continue**.
6. Connect the SMU Force to the calibration adapter J9.
7. Click **Continue**. The current setting test and current measurement test are executed.
8. Steps 6 and 7 are repeated until all of the selected SMUs are tested.
9. Steps 1 through 8 are repeated until all of the selected current ranges are tested.

Figure 2-12 Connection for SMU Current test (for 1 nA to 10 μA ranges)



SMU current test (for 100 μA to 1 A ranges)

This test consists of the current setting accuracy test and current measurement accuracy test; it verifies current setting and measurement accuracy.

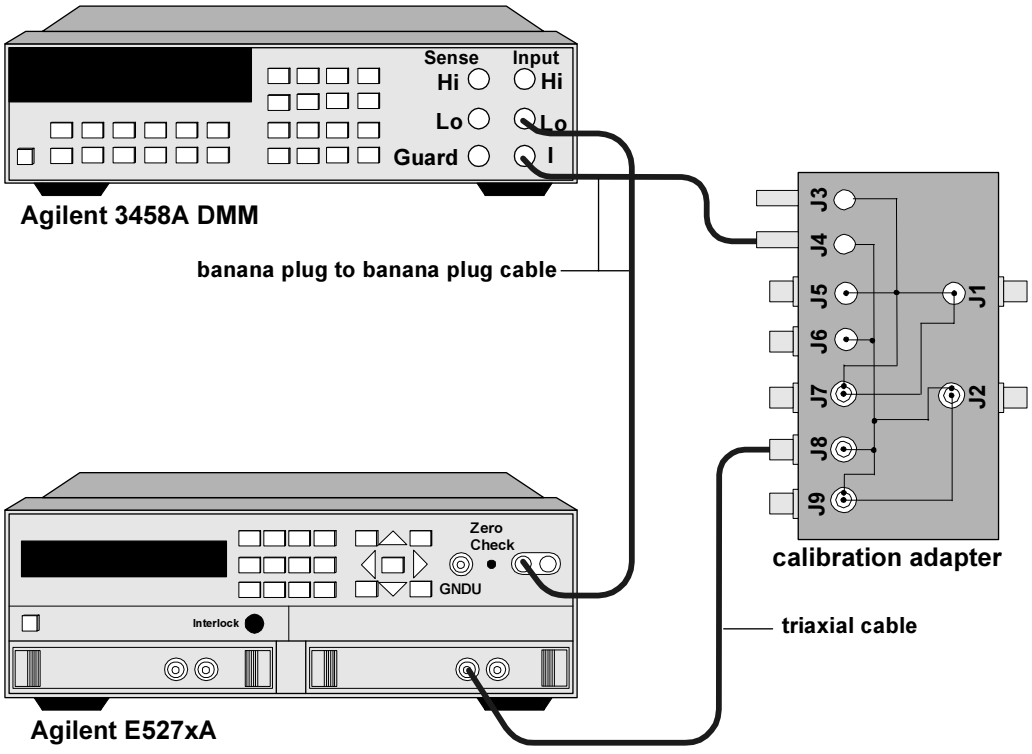
Required equipment

Triaxial cable (04142-61641)
Calibration adapter (04155-65041)
Banana plug to banana plug cable (Agilent 11058A); 2 each
Digital multimeter (Agilent 3458A)

Test procedure

1. Connect the DMM-Lo to the circuit common terminal on the mainframe front panel.
2. Connect the DMM-I to the calibration adapter J4.
3. Click **Continue**.
4. Connect the SMU Force to the calibration adapter J8 according to the displayed instruction.
5. Click **Continue**. The SMU current setting test and current measurement test are executed.
6. Steps 4 and 5 are repeated until all of the selected SMUs are tested.
7. Steps 1 through 6 are repeated until all of the selected current ranges are tested.

Figure 2-13 Connection for SMU current test (for 100 μA to 1 A ranges)



SMU CMR test

This test verifies the SMU common mode rejection accuracy.

Required equipment

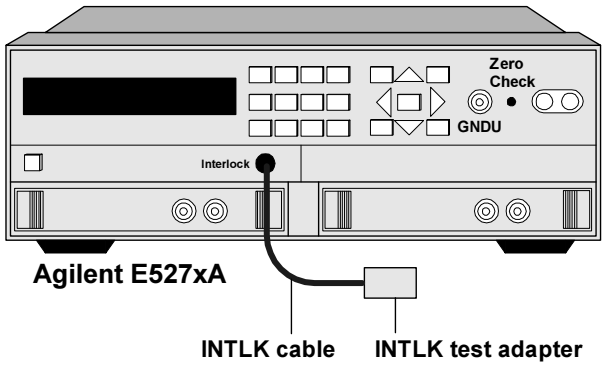
INTLK cable (04155-61614)

INTLK test adapter (04155-65043)

Test procedure

1. Disconnect all cables and plugs from SMU. (Set SMU to "open" condition.)
2. Connect the INTLK test adapter to the Interlock terminal on the E527xA front panel with the INTLK cable.
3. Set the INTLK test adapter switch to 1 (ON).
4. Click **Continue**. The SMU CMR test is executed.

Figure 2-14 Connection for SMU CMR test



ADC/SMU Calibration Procedure

This section describes the ADC/SMU calibration procedure, required equipment, cable connections for each calibration.

NOTE The ADC/SMU calibration must be done the following order.

1. ADC reference voltage calibration
2. ADC reference resistor calibration
3. SMU range resistor calibration

ADC reference voltage calibration

This calibration confirms the reference voltage values and updates them in the EEPROM of the GNDU/ADC module.

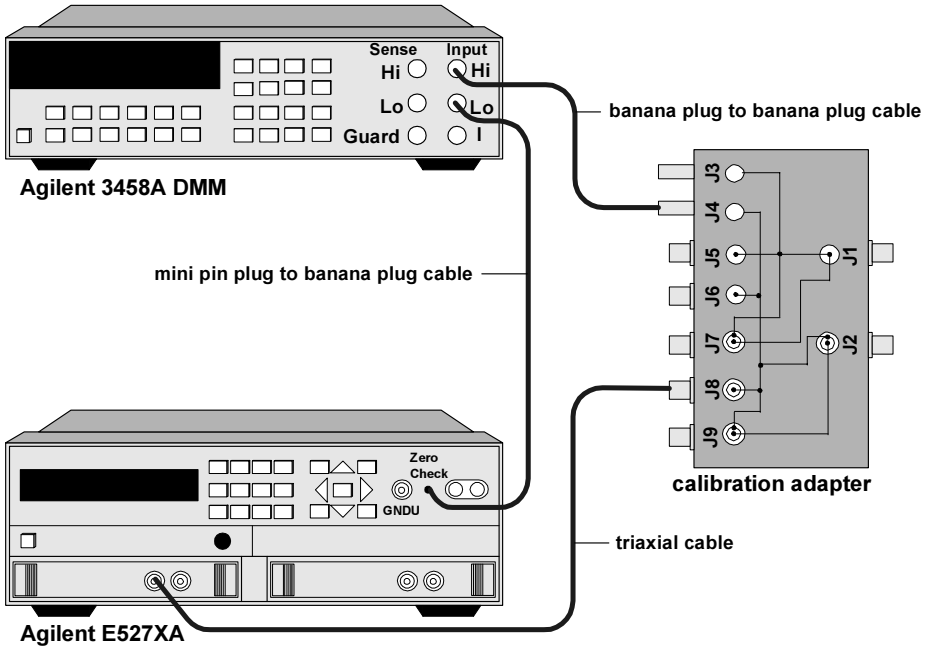
Required equipment

Triaxial cable (04142-61641)
Calibration adapter (04155-65041)
Mini pin plug to banana plug cable (04155-61648)
Banana plug to banana plug cable (Agilent 11058A)
Digital multimeter (Agilent 3458A)

Calibration procedure

1. Connect the DMM-Lo to the zero check terminal on the mainframe front panel.
2. Connect the DMM-Hi to the calibration adapter J4.
3. Click **Continue**. The ADC reference voltage calibration pre-test is executed.
4. Connect the SMU Force to the calibration adapter J8.
5. Click **Continue**. The ADC reference voltage calibration is executed.

Figure 2-15 Connection for reference voltage calibration



ADC reference resistor calibration

This calibration confirms the reference resistor values and updates them in the EEPROM of the GNDU/ADC module.

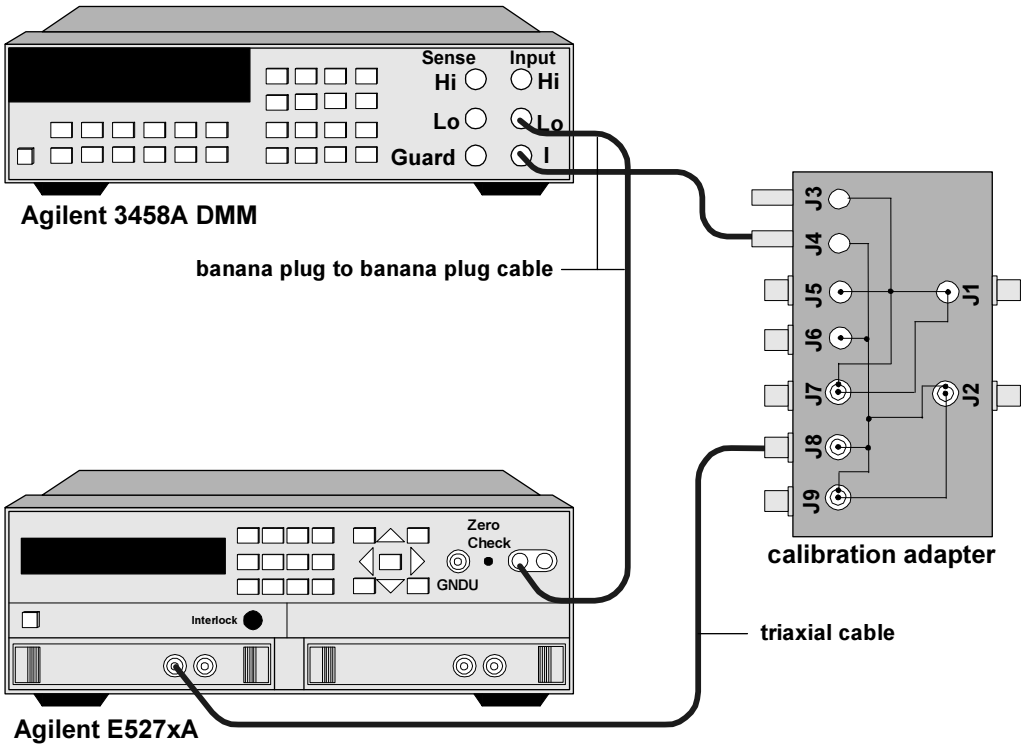
Required equipment

Triaxial cable (04142-61641)
Calibration adapter (04155-65041)
Banana plug to banana plug cable (Agilent 11058A); 2 each
Digital multimeter (Agilent 3458A)

Calibration procedure

1. Connect the DMM-Lo to the circuit common terminal on the mainframe front panel.
2. Connect the DMM-Hi to the calibration adapter J4.
3. Click **Continue**. The ADC reference resistor calibration pre-test is executed.
4. Connect the SMU Force to the calibration adapter J8.
5. Click **Continue**. The ADC reference resistor calibration is executed.

Figure 2-16 Connection for reference resistor calibration



SMU range resistor calibration

This calibration confirms the 500 megohm range resistor value on each SMU and updates them in the EEPROM of each SMU.

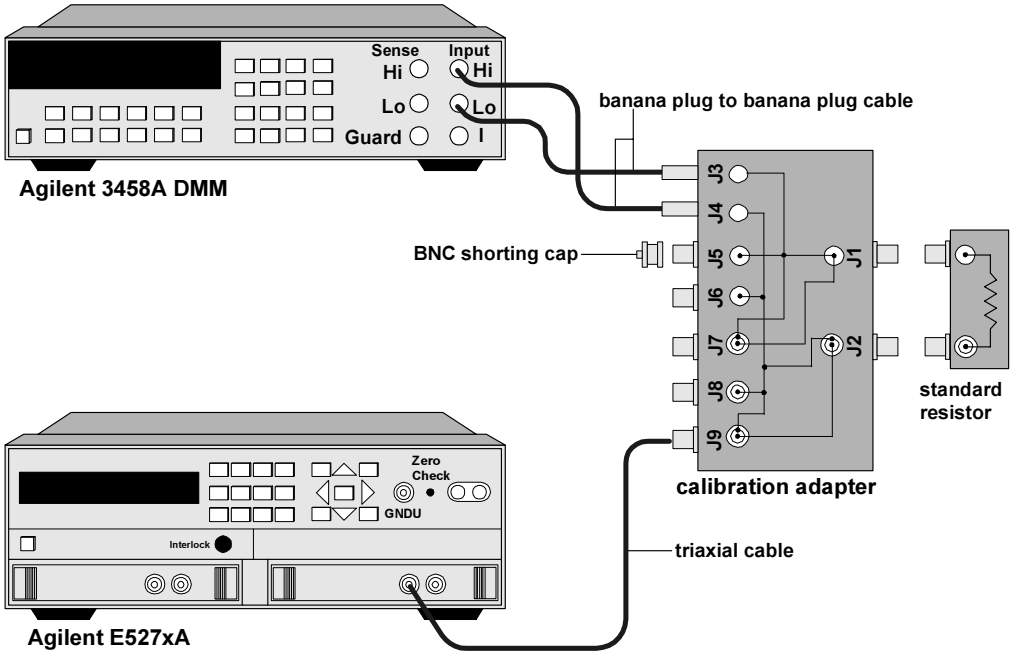
Required equipment

Triaxial cable (04142-61641)
Calibration adapter (04155-65041)
Banana plug to banana plug cable (Agilent 11058A); 2 each
BNC shorting cap (1250-0929)
Standard resistor set (Agilent 16353A)
Digital multimeter (Agilent 3458A)

Calibration procedure

1. Connect the DMM-Lo to the calibration adapter J3.
2. Connect the DMM-Hi to the calibration adapter J4.
3. Connect the BNC shorting cap to the calibration adapter J5.
4. Connect the 1 gigohm standard resistor to the calibration adapter J1 and J2.
5. Connect the SMU Force to the calibration adapter J9.
6. Click **Continue**. The SMU range resistor calibration is executed.
7. Steps 5 and 6 are repeated until all of the selected SMUs are calibrated.

Figure 2-17 Connection for SMU range resistor calibration



Performance Verification Theory

This section describes the operating theory, block diagram, and test limits for the performance verification.

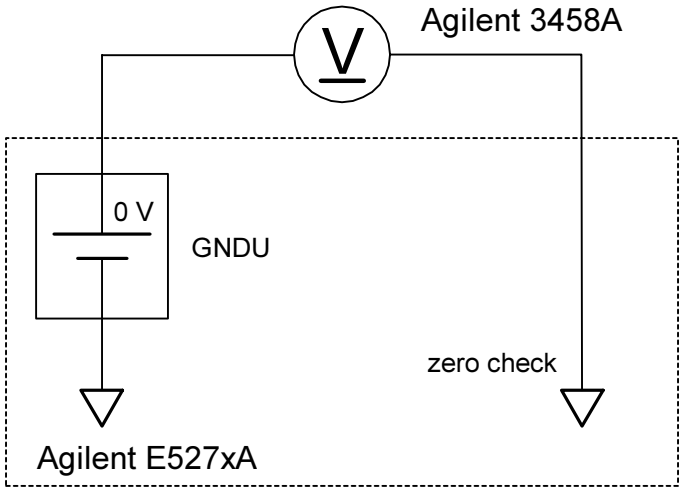
Self-test

The self-test operating theory is described in chapter 3. See “Troubleshooting Reference” in chapter 3.

GNDU voltage offset test

This test verifies the ground unit (GNDU) voltage offset accuracy.

Block diagram



Operating theory

1. The 3458A is set as follows:

Function	DCV
Range	100 mV
Auto zero	On
NPLC	10

2. The GNDU is set as follows:
3. The GNDU forces 0 V.
4. The 3458A waits for 100 milliseconds and measures the GNDU output voltage.
5. The 3458A measurement value is compared to the test limit.

Test limit

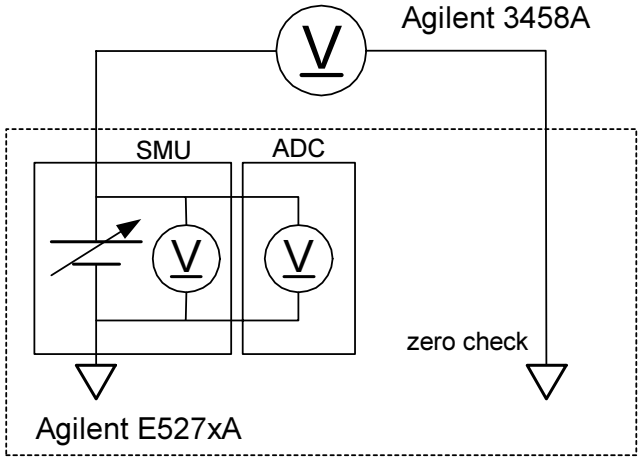
Table 2-1 GNDU voltage offset test limit

Nominal value	Accuracy	Uncertainty
0 V	±100 µV	2.82 µV

SMU voltage test

This test consists of the voltage force test and voltage measurement test; they verify the SMU voltage setting and measurement accuracy.

Block diagram



Operating theory

1. The 3458A is set as follows:

Function	DCV
Range	10 V (for SMU 2 V range) 100 V (for SMU 20 V, 40 V, and 100 V ranges) 1000 V (for HPSMU 200 V range)
Auto zero	On
NPLC	10

2. The SMU is set as follows:

Function	VFVM
Range	2 V, 20 V, 40 V, 100 V, or 200 V (HPSMU only)
Output current	0 V, ±FS (full scale), ±FS × 1.1
Current compliance	100 μA
Filter	On
Averaging samples	1
Integration time	Medium (NPLC = 1)

3. The SMU forces a certain voltage.
4. The 3458A, high-speed ADC, and high-resolution ADC wait for 100 milliseconds and measure SMU output voltage.
5. The 3458A measurement value is compared to the voltage force test limit. The measured value is also used as the reference for the voltage measurement test.
6. The high-speed ADC and high-resolution ADC measurement values are compared to the measurement test limit that is calculated by using 3458A measurement value.
7. Steps 1 through 6 are repeated until all of the selected ranges are tested.
8. Steps 1 through 6 are repeated until all of the selected SMUs are tested.

Test limit

Table 2-2 SMU voltage force test limit

Voltage range	Nominal value	Force accuracy	Uncertainty
2 V	0 V	±900 µV	3.28 µV
	±2 V	±1.5 mV	21.5 µV
	±2.2 V	±4.66 mV	23.4 µV
20 V	0 V	±4 mV	39.1 µV
	±20 V	±10 mV	243 µV
	±22 V	±13.6 mV	267 µV
40 V	0 V	±7 mV	39.1 µV
	±40 V	±19 mV	480 µV
	±44 V	±32.6 mV	527 µV
100 V	0 V	±15 mV	39.1 µV
	±100 V	±55 mV	1.19 mV
	±110 V[a]	±79.5 mV	1.32 mV
200 V[a]	0 V	±30 mV	133 µV
	±200 V	±120 mV	2.39 mV

a. HPSMU only

Table 2-3 SMU voltage measurement test limit (for MPSMU)

Voltage range	Nominal value	High-speed ADC measurement accuracy	High-resolution ADC measurement accuracy	Uncertainty
2 V	V_{dmm}[a] at SMU 0 V	±(V_{dmm}[a] × 0.0003 + 700 µV)	±(V_{dmm}[a] × 0.0002 + 700 µV)	7.52 µV
	V_{dmm}[a] at SMU ±2 V	±(V_{dmm}[a] × 0.0003 + 700 µV)	±(V_{dmm}[a] × 0.0002 + 700 µV)	22.2 µV
	V_{dmm}[a] at SMU ±2.2 V	±(V_{dmm}[a] × 0.0003 + 4 mV)	±(V_{dmm}[a] × 0.0002 + 2 mV)	24.0 µV
20 V	V_{dmm}[a] at SMU 0 V	±(V_{dmm}[a] × 0.0003 + 4 mV)	±(V_{dmm}[a] × 0.0002 + 2 mV)	52.4 µV
	V_{dmm}[a] at SMU ±20 V	±(V_{dmm}[a] × 0.0003 + 4 mV)	±(V_{dmm}[a]× 0.0002 + 2 mV)	246 µV
	V_{dmm}[a] at SMU ±22 V	±(V_{dmm}[a] × 0.0003 + 8 mV)	±(V_{dmm}[a] × 0.0002 + 3 mV)	269 µV
40 V	V_{dmm}[a] at SMU 0 V	±(V_{dmm}[a] × 0.0003 + 8 mV)	±(V_{dmm}[a] × 0.0002 + 3 mV)	59.7 µV
	V_{dmm}[a] at SMU ±40 V	±(V_{dmm}[a] × 0.0003 + 8 mV)	±(V_{dmm}[a] × 0.0002 + 3 mV)	482 µV
	V_{dmm}[a] at SMU ±44 V	±(V_{dmm}[a] × 0.0004 + 20 mV)	±(V_{dmm}[a] × 0.0003 + 5 mV)	529 µV
100 V	V_{dmm}[a] at SMU 0 V	±(V_{dmm}[a] × 0.0004 + 20 mV)	±(V_{dmm}[a] × 0.0003 + 5 mV)	130 µV
	V_{dmm}[a] at SMU ±100 V	±(V_{dmm}[a] × 0.0004 + 20 mV)	±(V_{dmm}[a] × 0.0003 + 5 mV)	1.20 mV

a. Measurement value of standard digital multimeter

Table 2-4 SMU voltage measurement test limit (for HPSMU)

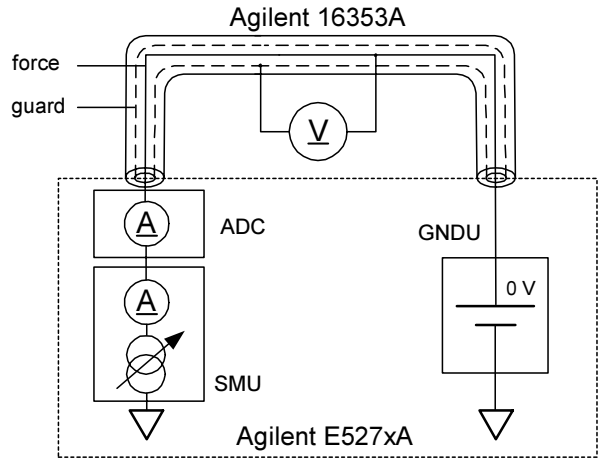
Voltage range	Nominal value	High-speed ADC measurement accuracy	High-resolution ADC measurement accuracy	Uncertainty
2 V	V_{dmm}[a] at SMU 0 V	±(V_{dmm}[a] × 0.0003 + 700 µV)	±(V_{dmm}[a] × 0.0002 + 700 µV)	8.11 µV
	V_{dmm}[a] at SMU ±2 V	±(V_{dmm}[a] × 0.0003 + 700 µV)	±(V_{dmm}[a] × 0.0002 + 700 µV)	22.3 µV
	V_{dmm}[a] at SMU ±2.2 V	±(V_{dmm}[a] × 0.0003 + 4 mV)	±(V_{dmm}[a] × 0.0002 + 2 mV)	24.2 µV
20 V	V_{dmm}[a] at SMU 0 V	±(V_{dmm}[a] × 0.0003 + 4 mV)	±(V_{dmm}[a]× 0.0002 + 2 mV)	40.8 µV
	V_{dmm}[a] at SMU ±20 V	±(V_{dmm}[a] × 0.0003 + 4 mV)	±(V_{dmm}[a]× 0.0002 + 2 mV)	244 µV
	V_{dmm}[a] at SMU ±22 V	±(V_{dmm}[a] × 0.0003 + 8 mV)	±(V_{dmm}[a] × 0.0002 + 3 mV)	267 µV
40 V	V_{dmm}[a] at SMU 0 V	±(V_{dmm}[a] × 0.0003 + 8 mV)	±(V_{dmm}[a] × 0.0002 + 3 mV)	42.2 µV
	V_{dmm}[a] at SMU ±40 V	±(V_{dmm}[a] × 0.0003 + 8 mV)	±(V_{dmm}[a] × 0.0002 + 3 mV)	480 µV
	V_{dmm}[a] at SMU ±44 V	±(V_{dmm}[a] × 0.0004 + 20 mV)	±(V_{dmm}[a] × 0.0003 + 5 mV)	528 µV
100 V	V_{dmm}[a] at SMU 0 V	±(V_{dmm}[a] × 0.0004 + 20 mV)	±(V_{dmm}[a] × 0.0003 + 5 mV)	51.1 µV
	V_{dmm}[a] at SMU ±100 V	±(V_{dmm}[a] × 0.0004 + 20 mV)	±(V_{dmm}[a] × 0.0003 + 5 mV)	1.19 mV
	V_{dmm}[a] at SMU ±110 V	±(V_{dmm}[a] × 0.00045 + 40 mV)	±(V_{dmm}[a] × 0.00035 + 10 mV)	1.31 mV
200 V	V_{dmm}[a] at SMU 0 V	±(V_{dmm}[a] × 0.00045 + 40 mV)	±(V_{dmm}[a] × 0.00035 + 10 mV)	147 µV
	V_{dmm}[a] at SMU ±200 V	±(V_{dmm}[a] × 0.00045 + 40 mV)	±(V_{dmm}[a] × 0.00035 + 10 mV)	2.39 mV

a. Measurement value of standard digital multimeter

SMU current pre-test

This test is the pre-measurement for the SMU current test; it verifies the guard potential offset voltage.

Block diagram



Operating theory

1. The 3458A is set as follows:

Function	DCV
Range	100 mV
Auto zero	On
NPLC	10

2. The SMU is set as follows:

Function	IFIM
Range	100 nA or 1 μA
Output current	±FS × 1.15, ±FS, and ±FS/10
Voltage compliance	2 V
Filter	On
Averaging samples	1
Integration time	Medium (NPLC = 1)

3. The SMU forces a certain current.
4. The 3458A waits for 100 milliseconds and measures the voltage difference between force and guard lines.
5. Steps 1 through 4 are repeated until all of the selected ranges are tested.
6. Steps 1 through 5 are repeated until all of the selected SMUs are tested.

Test limit

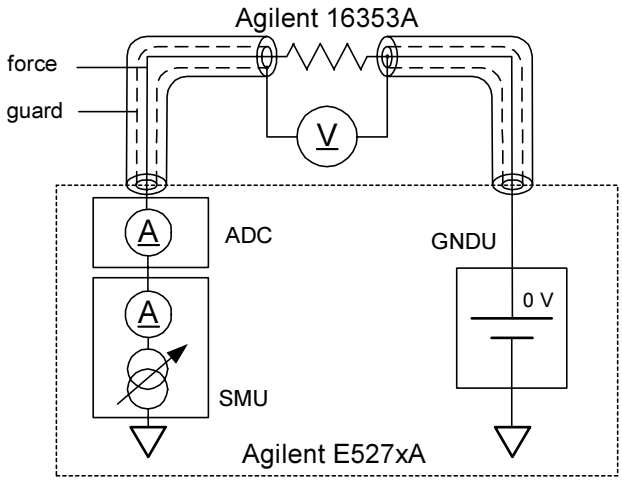
Table 2-5 SMU current pre-test limit

Current range	Output current	Nominal value	Accuracy	Uncertainty
100 nA	±115 nA	0 V	±1.3 mV	None
	±100 nA			
	±10 nA			
100 nA	±1.15 µA			
	±1 µA			
	±100 nA			

SMU current test (for 1 nA to 10 μA ranges)

This test consists of the current force test and current measurement test; they verify current force and measurement accuracy. Note that the SMU current pre-test must pass before this test.

Block diagram



Operating theory

1. The 3458A is set as follows:

Function	DCV
Range	1 V
Auto zero	On
NPLC	10

2. The SMU is set as follows:

Function	IFIM
Range	1 nA, 10 nA, 100 nA, 1 μA, or 10 μA
Output current	±FS × 1.15, ±FS, and ±FS/10
Voltage compliance	2 V
Filter	On
Averaging samples	1
Integration time	Medium (NPLC = 1)

3. The SMU forces a certain current.
4. The 3458A, high-speed ADC, and high-resolution ADC wait for 100 milliseconds and measure the voltage drop of the guard line (3458A) and SMU output current (ADCs).
5. The SMU output current is calculated by the 3458A measurement value and known resistance, and is compared to the current force test limit. The calculated value is also used as the reference for the current measurement test.
6. The high-speed ADC and high-resolution ADC measurement values are compared to the measurement test limit that is calculated by using the calculated SMU output value.
7. Steps 1 through 6 are repeated until all of the selected SMUs are tested.
8. Steps 1 through 8 are repeated until all of the selected ranges are tested.

Test limit

Table 2-6 SMU current force test limit

Current range	Nominal value	Force accuracy	Uncertainty
1 nA	±100 pA	±3.5 pA	69.7 fA
	±1 nA	±8 pA	561 fA
	±1.15 nA	±8.75 pA	643 fA
10 nA	±1 nA	±12 pA	690 fA
	±10 nA	±57 pA	6.42 pA
	±11.5 nA	±64.5 pA	7.38 pA
100 nA	±10 nA	±62 pA	2.44 pA
	±100 nA	±170 pA	12.0 pA
	±115 nA	±188 pA	13.7 pA
1 μA	±100 nA	±520 pA	29.6 pA
	±1 μA	±1.6 nA	207 pA
	±1.15 μA	±1.78 nA	238 pA
10 μA	±1 μA	±6.2 nA	223 pA
	±10 μA	±17 nA	729 pA
	±11.5 μA	±18.8 nA	829 pA

Table 2-7 SMU current measurement test limit (for MPSMU)

Current range	Nominal value	Measurement accuracy	Uncertainty
1 nA	I_{dmm}[a] at SMU ±100 pA	±(I_{dmm}[a] × 0.005 + 3 pA)	76.8 fA
	I_{dmm}[a] at SMU ±1 nA	±(Idmm[a] × 0.005 + 3 pA)	562 fA
	I_{dmm}[a] at SMU ±1.15 nA	±(Idmm[a] × 0.005 + 3 pA)	644 fA
10 nA	I_{dmm}[a] at SMU ±1 nA	±(I_{dmm}[a] × 0.005 + 5 pA)	693 fA
	I_{dmm}[a] at SMU ±10 nA	±(I_{dmm}[a] × 0.005 + 5 pA)	6.42 pA
	I_{dmm}[a] at SMU ±11.5 nA	±(I_{dmm}[a] × 0.005 + 5 pA)	7.38 pA
100 nA	I_{dmm}[a] at SMU ±10 nA	±(I_{dmm}[a] × 0.001 + 30 pA)	2.63 pA
	I_{dmm}[a] at SMU ±100 nA	±(I_{dmm}[a] × 0.001 + 30 pA)	12.0 pA
	I_{dmm}[a] at SMU ±100 nA	±(I_{dmm}[a] × 0.001 + 30 pA)	13.7 pA
1 μA	I_{dmm}[a] at SMU ±100 nA	±(I_{dmm}[a] × 0.001 + 200 pA)	29.8 pA
	I_{dmm}[a] at SMU ±1 μA	±(I_{dmm}[a] × 0.001 + 200 pA)	207 pA
	I_{dmm}[a] at SMU ±1.15 μA	±(I_{dmm}[a] × 0.001 + 200 pA)	238 pA
10 μA	I_{dmm}[a] at SMU ±1 μA	±(I_{dmm}[a] × 0.001 + 3 nA)	242 pA
	I_{dmm}[a] at SMU ±10 μA	±(I_{dmm}[a] × 0.001 + 3 nA)	735 pA
	I_{dmm}[a] at SMU ±11.5 μA	±(I_{dmm}[a] × 0.001 + 3 nA)	835 pA

a. Measurement value of standard digital multimeter

Table 2-8 SMU current measurement test limit

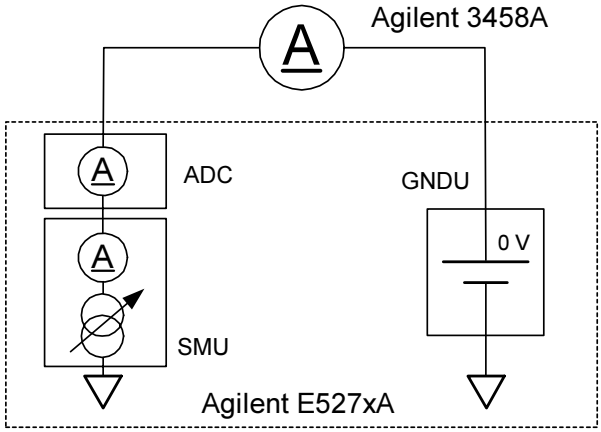
Current range	Nominal value	Measurement accuracy	Uncertainty
1 nA	I_{dmm}[a] at SMU ±100 pA	±(I_{dmm}[a] × 0.005 + 3 pA)	75.9 fA
	I_{dmm}[a] at SMU ±1 nA	±(Idmm[a] × 0.005 + 3 pA)	562 fA
	I_{dmm}[a] at SMU ±1.15 nA	±(Idmm[a] × 0.005 + 3 pA)	644 fA
10 nA	I_{dmm}[a] at SMU ±1 nA	±(I_{dmm}[a] × 0.005 + 5 pA)	69.3 fA
	I_{dmm}[a] at SMU ±10 nA	±(I_{dmm}[a] × 0.005 + 5 pA)	6.42 pA
	I_{dmm}[a] at SMU ±11.5 nA	±(I_{dmm}[a] × 0.005 + 5 pA)	7.38 pA
100 nA	I_{dmm}[a] at SMU ±10 nA	±(I_{dmm}[a] × 0.001 + 30 pA)	2.60 pA
	I_{dmm}[a] at SMU ±100 nA	±(I_{dmm}[a] × 0.001 + 30 pA)	12.0 pA
	I_{dmm}[a] at SMU ±100 nA	±(I_{dmm}[a] × 0.001 + 30 pA)	13.7 pA
1 µA	I_{dmm}[a] at SMU ±100 nA	±(I_{dmm}[a] × 0.001 + 200 pA)	29.7 pA
	I_{dmm}[a] at SMU ±1 µA	±(I_{dmm}[a] × 0.001 + 200 pA)	207 pA
	I_{dmm}[a] at SMU ±1.15 µA	±(I_{dmm}[a] × 0.001 + 200 pA)	238 pA
10 µA	I_{dmm}[a] at SMU ±1 µA	±(I_{dmm}[a] × 0.001 + 3 nA)	236 pA
	I_{dmm}[a] at SMU ±10 µA	±(I_{dmm}[a] × 0.001 + 3 nA)	733 pA
	I_{dmm}[a] at SMU ±11.5 µA	±(I_{dmm}[a] × 0.001 + 3 nA)	833 pA

a. Measurement value of standard digital multimeter

SMU current test (for 100 μA to 1 A ranges)

This test consists of the current force test and current measurement test; they verify current force and measurement accuracy.

Block diagram



Operating theory

1. The 3458A is set as follows:

Function	DCI
Range	100 μA (for SMU 100 μA range) 1 mA (for SMU 1 mA range) 10 mA (for SMU 10 mA range) 100 mA (for SMU 100 mA range) 1 A (for SMU 200 mA and 1 A ranges)
Auto zero	On
NPLC	10

2. The SMU is set as follows:

Function	IFIM
Range	100 μA, 1 mA 10 mA, 100 mA, 200 mA (MPSMU only), or 1 A (HPSMU only)
Output current	±FS × 1.15 (except 200 mA and 1 A ranges), ±FS, and ±FS/10
Voltage compliance	2 V (for 100 μA, 1 mA 10 mA, 100 mA, and 200 mA ranges) 5 V (for 1 A range)
Filter	On
Averaging samples	1
Integration time	medium (NPLC = 1)

3. The SMU forces a certain current.
4. The 3458A, high-speed ADC, and high-resolution ADC wait for 100 milliseconds and measure the SMU output current.
5. The 3458A measurement value is compared to the current force test limit. The measured value is also used as the reference for the current measurement test.
6. The high-speed ADC and high-resolution ADC measurement value is compared to the measurement test limit that is calculated by using 3458A measurement value.
7. Steps 1 through 6 are repeated until all of the selected ranges are tested.
8. Steps 1 through 6 are repeated until all of the selected SMUs are tested.

Test limit

Table 2-9 SMU current force test limit

Current range	Nominal value	Force accuracy	Uncertainty
100 µA	±10 µA	±52 nA	975 pA
	±100 µA	±160 nA	2.56 nA
	±115 µA	±178 nA	2.90 nA
1 mA	±100 µA	±620 nA	6.56 nA
	±1 mA	±1.8 µA	24.6 nA
	±1.15 mA	±1.88 µA	28.1 nA
10 mA	±1 mA	±5.2 µA	65.6 nA
	±10 mA	±16 µA	246 nA
	±11.5 mA	±17.8 µA	280 nA
100 mA	±10 mA	±62 µA	735 nA
	±100 mA	±170 µA	4.13 µA
	±115 mA	±188 µA	4.73 µA
200 mA[a]	±20 mA	±124 µA	12.0 µA
	±200 mA	±340 µA	28.0 µA
1 A[b]	±100 mA	±1 mA	17.3 µA
	±1 A	±5.5 mA	128 µA

a. MPSMU only
b. HPSMU only

Table 2-10 SMU current measurement test limit (for MPSMU)

Current range	Nominal value	Measurement accuracy	Uncertainty
100 µA	I_{dmm}[a] at SMU ±10 µA	±(I_{dmm}[a] × 0.001 + 20 nA)	1.10 nA
	I_{dmm}[a] at SMU ±100 µA	±(I_{dmm}[a] × 0.001 + 20 nA)	2.61 nA
	I_{dmm}[a] at SMU ±115 µA	±(I_{dmm}[a] × 0.001 + 20 nA)	2.94 nA
1 mA	I_{dmm}[a] at SMU ±100 µA	±(I_{dmm}[a] × 0.001 + 300 nA)	11.0 nA
	I_{dmm}[a] at SMU ±1 mA	±(I_{dmm}[a] × 0.001 + 300 nA)	26.1 nA
	I_{dmm}[a] at SMU ±1.15 mA	±(I_{dmm}[a] × 0.001 + 300 nA)	29.4 nA
10 mA	I_{dmm}[a] at SMU ±1 mA	±(I_{dmm}[a] × 0.001 + 2 µA)	72.1 nA
	I_{dmm}[a] at SMU ±10 mA	±(I_{dmm}[a] × 0.001 + 2 µA)	248 nA
	I_{dmm}[a] at SMU ±11.5 mA	±(I_{dmm}[a] × 0.001 + 2 µA)	282 nA
100 mA	I_{dmm}[a] at SMU ±10 mA	±(I_{dmm}[a] × 0.001 + 30 µA)	1.15 µA
	I_{dmm}[a] at SMU ±100 mA	±(I_{dmm}[a] × 0.001 + 30 µA)	4.22 µA
	I_{dmm}[a] at SMU ±115 mA	±(I_{dmm}[a] × 0.001 + 30 µA)	4.82 µA
200 mA	I_{dmm}[a] at SMU ±20 mA	±(I_{dmm}[a] × 0.001 + 60 µA)	12.4 µA
	I_{dmm}[a] at SMU ±200 mA	±(I_{dmm}[a] × 0.001 + 60 µA)	28.2 µA

a. Measurement value of standard digital multimeter

Table 2-11 SMU current measurement test limit

Current range	Nominal value	Measurement accuracy	Uncertainty
100 μA	I_{dmm}[a] at SMU ±10 μA	±(I_{dmm}[a] × 0.001 + 20 nA)	993 pA
	I_{dmm}[a] at SMU ±100 μA	±(I_{dmm}[a] × 0.001 + 20 nA)	2.57 nA
	I_{dmm}[a] at SMU ±115 μA	±(I_{dmm}[a] × 0.001 + 20 nA)	2.90 nA
1 mA	I_{dmm}[a] at SMU ±100 μA	±(I_{dmm}[a] × 0.001 + 300 nA)	9.59 nA
	I_{dmm}[a] at SMU ±1 mA	±(I_{dmm}[a] × 0.001 + 300 nA)	25.6 nA
	I_{dmm}[a] at SMU ±1.15 mA	±(I_{dmm}[a] × 0.001 + 300 nA)	28.9 nA
10 mA	I_{dmm}[a] at SMU ±1 mA	±(I_{dmm}[a] × 0.001 + 2 μA)	67.7 nA
	I_{dmm}[a] at SMU ±10 mA	±(I_{dmm}[a] × 0.001 + 2 μA)	246 nA
	I_{dmm}[a] at SMU ±11.5 mA	±(I_{dmm}[a] × 0.001 + 2 μA)	281 nA
100 mA	I_{dmm}[a] at SMU ±10 mA	±(I_{dmm}[a] × 0.001 + 30 μA)	1.03 μA
	I_{dmm}[a] at SMU ±100 mA	±(I_{dmm}[a] × 0.001 + 30 μA)	4.19 μA
	I_{dmm}[a] at SMU ±115 mA	±(I_{dmm}[a] × 0.001 + 30 μA)	4.79 μA
1 A	I_{dmm}[a] at SMU ±100 mA	±(I_{dmm}[a] × 0.005 + 300 μA)	17.4 μA
	I_{dmm}[a] at SMU ±1 A	±(I_{dmm}[a] × 0.005 + 300 μA)	128 μA

a. Measurement value of standard digital multimeter

SMU CMR test

This test is a part of SMU CMR test, and verifies the SMU common mode rejection accuracy.

Operating theory

1. The SMU is set as follows:

Function	VFIM
Range	100 V
Output voltage	±100 V
Current compliance	10 mA
Filter	On
Averaging samples	1
Integration time	Medium (NPLC = 1)

2. The SMU forces the −100 V.
3. The SMU waits for 10 seconds and measures its own output (leakage) current (SMU_{im}).
4. The SMU forces the +100 V.
5. The SMU waits for 10 seconds and measures its own output (leakage) current (SMU_{ip}).
6. The CMR is calculated as follows, and the calculated CMR is compared to the test limit.

$$CMR = SMU_{im} - SMU_{ip}$$

Test limit

Table 2-12 SMU CMR test limit

Nominal value	Accuracy	Uncertainty
0 A	±40 μA	None

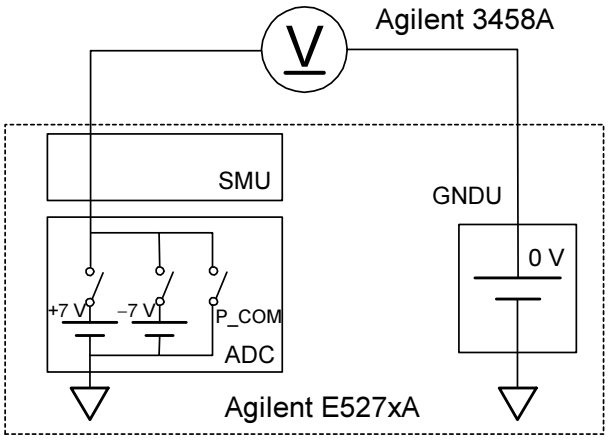
ADC/SMU Calibration Theory

This section describes the operating theory, block diagram, and calibration limits for the ADC/SMU calibration.

ADC reference voltage calibration

There are two reference voltages, +7 V and –7 V, on the GNDU/ADC board. This calibration confirms the reference voltage values and updates the values in the EEPROM on the GNDU/ADC module.

Block diagram



Operating theory

1. The calibration program executes self-test for each SMU, and use one of the SMU for connecting reference voltage in the reference voltage calibration.
2. The 3458A is set as follows:

Function	DCV
Range	10 V
Auto zero	On
NPLC	100

3. The reference potential common of the circuit (P_COM) is connected to the SMU1 port, and the 3458A measures the voltage of the reference potential common (V_{com}).
4. The +7 V reference voltage is connected to the SMU port, and the 3458A measures the output voltage (V_p).
5. The –7 V reference voltage is connected to the SMU port, and the 3458A measures the output voltage (V_n).
6. The voltages of ±7 V are calculated as follows:

$$V_{refp} = V_p - V_{com}$$
$$V_{refn} = V_n - V_{com}$$

7. Steps 3 through 6 are repeated three times.
8. The average value of the three measurements is compared to the accuracy limit.
9. The dispersion of the three measurements is compared to the dispersion limit.
10. After the calibration completes, the calibrated values and date are updated in the EEPROM of the GNDU/ADC module.

Calibration limit

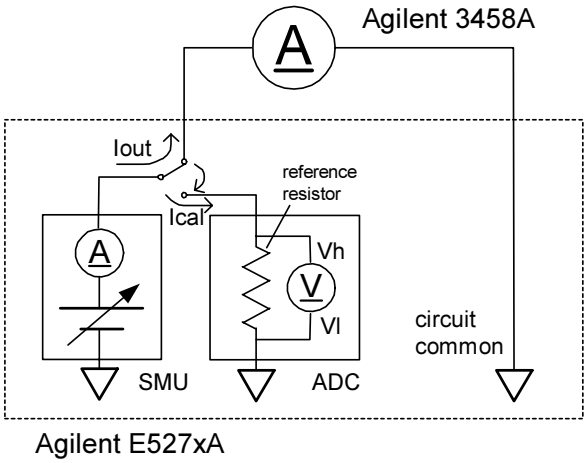
Table 2-13 ADC reference voltage calibration limit

Reference voltage	Nominal value	Accuracy	Dispersion
+7 V	6.95 V	± 0.42 V	≤ 30 μV
–7 V	–6.95 V	± 0.42 V	≤ 30 μV

ADC reference resistor calibration

There are five reference resistors: 100 ohm, 10 kilohm, 1 megohm, and 100 megohm, on the GNDU/ADC board. This calibration confirms the reference resistor values and updates the values in the EEPROM on the GNDU/ADC module.

Block diagram



Operating theory

1. The calibration program executes CMR test for each SMU, and use the best CMR accuracy SMU for the voltage source of the reference resistor calibration.
2. The 3458A is set as follows:

Function	DCI
Range	100 mA
Auto zero	On
NPLC:	100

3. The SMU is connected to the SMU output, and forces a certain voltage.
4. The 3458A and SMU measure the output current (I_{dmm} and I_{out}).
5. The SMU is connected to the reference resistor, and forces a certain voltage.
6. The SMU measures its own current (I_{cal}).
7. The high-resolution ADC measures the voltage of reference resistor high side (V_h).
8. The high-resolution ADC measures the voltage of reference resistor low side (V_l).
9. The resistance value is calculated as follows:

$$R = \frac{(V_h - V_l) \times I_{out}}{I_{dmm} \times I_{cal}}$$

10. Steps 2 through 9 are repeated three times.
11. The average value of three measurements is compared to the calibration limit.
12. The dispersion of the three measurements is compared to the calibration limit.
13. Steps 1 through 11 are repeated until all of the reference resistors are calibrated.
14. After the calibration completes, the calibrated values and date are updated in the EEPROM on the GNDU/ADC module.

Calibration limit

Table 2-14 ADC reference resistor calibration pre-test (CMR test) limit

Nominal value	Accuracy
0 A	±1 nA

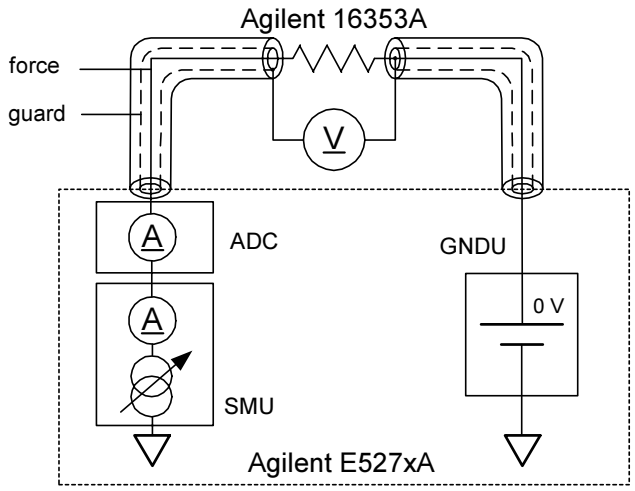
Table 2-15 ADC reference resistor calibration limit

Reference Resistor	Nominal Value	Accuracy	Dispersion
100 Ω	100 Ω	±500 mΩ	≤10 mΩ
10 kΩ	10 kΩ	±50 Ω	≤500 mΩ
1 MΩ	1 MΩ	±5 kΩ	≤50 Ω
100 MΩ	100 MΩ	±1 MΩ	≤50 kΩ

SMU range resistor calibration

This calibration confirms the 500 megohm SMU range resistor value, which is used for 1 nA and 10 nA ranges, and updates them in the EEPROM of the SMU module.

Block diagram



Operation theory

1. The 3458A is set as follows:

Function	DCV
Range	10 V
Auto zero	On
NPLC	10

2. The SMU is set as follows:

Function	IFIM
Range	10 nA
Output current	10 nA
Voltage compliance	2 V
Filter	On
Averaging samples	1
Integration time	Long (NPLC=5)

3. The 3458A and high-resolution ADC wait for 5 seconds and measure the guard offset voltage (V_2) and the SMU output current (I_2).

4. The SMU is set as follows:

Function	IFIM
Range	10 nA
Output current	10 nA
Voltage compliance	20 V
Filter	On
Averaging samples	1
Integration time	Long (NPLC=5)

5. The 3458A and high-resolution ADC wait for 5 seconds and measure the voltage drop of 1 gigohm standard resistor (V_{20}) and SMU output current (I_{20}).
6. The measurement values are compared to the calibration limit.
7. The gain of the SMU measurement and 3458A is calculated as follows:

$$Gain = \frac{V_{20} - V_2}{(I_{20} - I_2) \times R}$$

8. Steps 1 through 9 are repeated until all of the selected SMUs are calibrated.
9. After the calibration completes, the calibrated values (gain) and date are updated in the EEPROM on the SMU.

Calibration limit

Table 2-16 SMU range resistor calibration limit

Variable	Nominal Value	Accuracy
V_2	2.0 V	±0.20 V
V_{20}	20 V	±2 V
I_2	2 nA	±0.2 nA
I_{20}	10 nA	±1 nA

Printing Test Result

The test results can be printed out on the paper or can be shown on the display. To report the test results, use the following procedure.

1. Open `C:\Program Files\Performance Verification\pvview5270.xls` by using the Microsoft® Excel.
2. Click **Make Test Data Sheet**.
3. Choose the test result file which you want to display. Then click **Open**.
4. The `pvview5270.xls` automatically formats the test result data.

Figure 2-18 through figure 2-27 shows an example of the formatted test data.

Figure 2-18 Agilent E5273A test record example (1/10)

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PERFORMANCE TEST RECORD

Agilent Technologies

Test Facility:
Agilent Technologies Hachioji
Semiconductor Test Division

Report Number: 1
Date: 2002/11/7
Customer Name: Agilent Technologies
Oparator Name: Tanaka

Ambient temperature: 23.5 deg
Relative Humidity: 48 %
Line Frequency: 50 Hz

Agilent E5273A 2 Channel (High Power, Medium Power) Source/Monitor Unit

Serial Number: JP10L00101
Firmware Revision A.00.31
Options:

Slot Configuration:

		Model No.	Serial No.
Slot 1:	MPSMU	E5281A	
Slot 2:	HPSMU	E5280A	
Slot 3:			
Slot 4:			
Slot 5:			
Slot 6:			
Slot 7:			
Slot 8			

Test Equipment Used:

Description	Model No.	Serial No.	Trace No.	Cal Due Date
Digital Multimeter	Agilent 3458A	2823A01425	140-334	2003/2/6
Standerd Resister Set	Agilent 16353A	JP10A00187	HST-004	2004/5/30

Hachioji Semiconductor Test division, Agilent Technologies Japan, Ltd.
9-1, Takakura-cho, Hachioji, Tokyo, 192-8510 Japan

Figure 2-19 Agilent E5273A test record example (2/10)

GNDU Accuracy Test

V offset Test

GNDU		Minimum	Results	Maximum		Pass/Fail
	DVM meas	-100.00000 uV	20.60000 uV	100.00000 uV	0.00000 uV	Pass

Figure 2-20 Agilent E5273A test record example (3/10)

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MPSMU Accuracy Test

SMU voltage Test

Slot 1		Minimum	Results	Maximum	Uncertainty	Pass/Fail
2V range	-2.2V set DVM meas	-2.20466 V	-2.20044 V	-2.19534 V	0.00000 V	Pass
	-2.2V set H-RESOLN ADC meas	-2.20158 V	-2.20050 V	-2.19930 V	0.00000 V	Pass
	-2.2V set H-SPEED ADC meas	-2.20180 V	-2.20060 V	-2.19908 V	0.00000 V	Pass
	-2V set DVM meas	-2.00150 V	-2.00000 V	-1.99850 V	0.00000 V	Pass
	-2V set H-RESOLN ADC meas	-2.00110 V	-2.00020 V	-1.99890 V	0.00000 V	Pass
	-2V set H-SPEED ADC meas	-2.00130 V	-2.00020 V	-1.99870 V	0.00000 V	Pass
	0V set DVM meas	-900.00000 uV	10.80000 uV	900.00000 uV	0.00000 uV	Pass
	0V set H-RESOLN ADC meas	-689.17500 uV	100.00000 uV	710.82500 uV	0.00000 uV	Pass
	0V set H-SPEED ADC meas	-689.17500 uV	100.00000 uV	710.82500 uV	0.00000 uV	Pass
	2V set DVM meas	1.99850 V	1.99998 V	2.00150 V	0.00000 V	Pass
	2V set H-RESOLN ADC meas	1.99888 V	2.00020 V	2.00108 V	0.00000 V	Pass
	2V set H-SPEED ADC meas	1.99868 V	2.00020 V	2.00128 V	0.00000 V	Pass
	2.2V set DVM meas	2.19534 V	2.20002 V	2.20466 V	0.00000 V	Pass
	2.2V set H-RESOLN ADC meas	2.19888 V	2.20030 V	2.20116 V	0.00000 V	Pass
	2.2V set H-SPEED ADC meas	2.19866 V	2.20020 V	2.20138 V	0.00000 V	Pass
20V range	-22V set DVM meas	-22.01360 V	-22.00009 V	-21.98640 V	0.00000 V	Pass
	-22V set H-RESOLN ADC meas	-22.00649 V	-22.00300 V	-21.99369 V	0.00000 V	Pass
	-22V set H-SPEED ADC meas	-22.01069 V	-22.00200 V	-21.98949 V	0.00000 V	Pass
	-20V set DVM meas	-20.01000 V	-20.00025 V	-19.99000 V	0.00000 V	Pass
	-20V set H-RESOLN ADC meas	-20.00625 V	-20.00200 V	-19.99425 V	0.00000 V	Pass
	-20V set H-SPEED ADC meas	-20.01025 V	-20.00200 V	-19.99025 V	0.00000 V	Pass
	0V set DVM meas	-4.00000 mV	-0.15083 mV	4.00000 mV	0.00000 mV	Pass
	0V set H-RESOLN ADC meas	-2.15083 mV	0.00000 mV	1.84917 mV	0.00000 mV	Pass
	0V set H-SPEED ADC meas	-4.15083 mV	0.00000 mV	3.84917 mV	0.00000 mV	Pass
	20V set DVM meas	19.99000 V	19.99964 V	20.01000 V	0.00000 V	Pass
	20V set H-RESOLN ADC meas	19.99364 V	20.00200 V	20.00564 V	0.00000 V	Pass
	20V set H-SPEED ADC meas	19.98964 V	20.00200 V	20.00964 V	0.00000 V	Pass
	22V set DVM meas	21.98640 V	21.99957 V	22.01360 V	0.00000 V	Pass
	22V set H-RESOLN ADC meas	21.99317 V	22.00200 V	22.00597 V	0.00000 V	Pass
	22V set H-SPEED ADC meas	21.98897 V	22.00200 V	22.01017 V	0.00000 V	Pass
40V range	-44V set DVM meas	-44.03260 V	-44.00121 V	-43.96740 V	0.00000 V	Pass
	-44V set H-RESOLN ADC meas	-44.01301 V	-44.00800 V	-43.98941 V	0.00000 V	Pass
	-44V set H-SPEED ADC meas	-44.02241 V	-44.00600 V	-43.98001 V	0.00000 V	Pass
	-40V set DVM meas	-40.01900 V	-39.99961 V	-39.98100 V	0.00000 V	Pass
	-40V set H-RESOLN ADC meas	-40.01061 V	-40.00600 V	-39.98861 V	0.00000 V	Pass
	-40V set H-SPEED ADC meas	-40.01961 V	-40.00600 V	-39.97961 V	0.00000 V	Pass
	0V set DVM meas	-7.00000 mV	0.16287 mV	7.00000 mV	0.00000 mV	Pass
	0V set H-RESOLN ADC meas	-2.83713 mV	0.00000 mV	3.16287 mV	0.00000 mV	Pass
	0V set H-SPEED ADC meas	-7.83713 mV	0.00000 mV	8.16287 mV	0.00000 mV	Pass
	40V set DVM meas	39.98100 V	39.99795 V	40.01900 V	0.00000 V	Pass
	40V set H-RESOLN ADC meas	39.98695 V	40.00200 V	40.00895 V	0.00000 V	Pass
	40V set H-SPEED ADC meas	39.97795 V	40.00200 V	40.01795 V	0.00000 V	Pass
	44V set DVM meas	43.96740 V	43.99995 V	44.03260 V	0.00000 V	Pass
	44V set H-RESOLN ADC meas	43.98815 V	44.00600 V	44.01175 V	0.00000 V	Pass
	44V set H-SPEED ADC meas	43.97875 V	44.00600 V	44.02115 V	0.00000 V	Pass
100V range	-100V set DVM meas	-100.05500 V	-99.99815 V	-99.94500 V	0.00000 V	Pass
	-100V set H-RESOLN ADC meas	-100.03315 V	-100.01500 V	-99.96315 V	0.00000 V	Pass
	-100V set H-SPEED ADC meas	-100.04815 V	-100.01500 V	-99.94815 V	0.00000 V	Pass
	0V set DVM meas	-15.00000 mV	0.92906 mV	15.00000 mV	0.00000 mV	Pass
	0V set H-RESOLN ADC meas	-4.07094 mV	0.00000 mV	5.92906 mV	0.00000 mV	Pass
	0V set H-SPEED ADC meas	-19.07094 mV	0.00000 mV	20.92906 mV	0.00000 mV	Pass
	100V set DVM meas	99.94500 V	99.99838 V	100.05500 V	0.00000 V	Pass
	100V set H-RESOLN ADC meas	99.96338 V	100.01000 V	100.03338 V	0.00000 V	Pass
	100V set H-SPEED ADC meas	99.94838 V	100.01000 V	100.04838 V	0.00000 V	Pass

Figure 2-21 Agilent E5273A test record example (4/10)

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SMU current Test

Slot 1		Minimum	Results	Maximum	Uncertainty	Pass/Fail
pre-test 100nA range	-115nA set Offset V	-1.00000 mV	-0.03780 mV	1.00000 mV		Pass
	-100nA set Offset V	-1.00000 mV	-0.03730 mV	1.00000 mV		Pass
	-10nA set Offset V	-1.00000 mV	-0.03260 mV	1.00000 mV		Pass
	10nA set Offset V	-1.00000 mV	-0.03170 mV	1.00000 mV		Pass
	100nA set Offset V	-1.00000 mV	-0.02710 mV	1.00000 mV		Pass
	115nA set Offset V	-1.00000 mV	-0.02650 mV	1.00000 mV		Pass
pre-test 1uA range	-1.15uA set Offset V	-1.00000 mV	-0.09500 mV	1.00000 mV		Pass
	-1uA set Offset V	-1.00000 mV	-0.08890 mV	1.00000 mV		Pass
	-100nA set Offset V	-1.00000 mV	-0.03730 mV	1.00000 mV		Pass
	100nA set Offset V	-1.00000 mV	-0.02710 mV	1.00000 mV		Pass
	1uA set Offset V	-1.00000 mV	-0.01310 mV	1.00000 mV		Pass
	1.15uA set Offset V	-1.00000 mV	-0.01080 mV	1.00000 mV		Pass
1nA range	-1.15nA set DVM meas	-1.16000 nA	-1.15000 nA	-1.14000 nA	0.00000 nA	Pass
	-1.15nA set H-RESOLN ADC meas	-1.16000 nA	-1.15000 nA	-1.14000 nA	0.00000 nA	Pass
	-1.15nA set H-SPEED ADC meas	-1.16000 nA	-1.15000 nA	-1.14000 nA	0.00000 nA	Pass
	-1nA set DVM meas	-1.01000 nA	-1.00000 nA	-0.99200 nA	0.00000 nA	Pass
	-1nA set H-RESOLN ADC meas	-1.01000 nA	-1.00000 nA	-0.99200 nA	0.00000 nA	Pass
	-1nA set H-SPEED ADC meas	-1.01000 nA	-1.00000 nA	-0.99200 nA	0.00000 nA	Pass
	-100pA set DVM meas	-104.00000 pA	-100.00000 pA	-96.50000 pA	0.00000 pA	Pass
	-100pA set H-RESOLN ADC meas	-104.00000 pA	-100.00000 pA	-96.50000 pA	0.00000 pA	Pass
	-100pA set H-SPEED ADC meas	-104.00000 pA	-100.00000 pA	-96.50000 pA	0.00000 pA	Pass
	100pA set DVM meas	96.50000 pA	100.00000 pA	104.00000 pA	0.00000 pA	Pass
	100pA set H-RESOLN ADC meas	96.60000 pA	100.00000 pA	104.00000 pA	0.00000 pA	Pass
	100pA set H-SPEED ADC meas	96.60000 pA	100.00000 pA	104.00000 pA	0.00000 pA	Pass
	1nA set DVM meas	0.99200 nA	1.00000 nA	1.01000 nA	0.00000 nA	Pass
	1nA set H-RESOLN ADC meas	0.99200 nA	1.00000 nA	1.01000 nA	0.00000 nA	Pass
	1nA set H-SPEED ADC meas	0.99200 nA	1.00000 nA	1.01000 nA	0.00000 nA	Pass
	1.15nA set DVM meas	1.14000 nA	1.15000 nA	1.16000 nA	0.00000 nA	Pass
	1.15nA set H-RESOLN ADC meas	1.14000 nA	1.15000 nA	1.16000 nA	0.00000 nA	Pass
	1.15nA set H-SPEED ADC meas	1.14000 nA	1.15000 nA	1.16000 nA	0.00000 nA	Pass
10nA range	-11.5nA set DVM meas	-11.60000 nA	-11.50000 nA	-11.40000 nA	0.00000 nA	Pass
	-11.5nA set H-RESOLN ADC meas	-11.60000 nA	-11.50000 nA	-11.50000 nA	0.00000 nA	Pass
	-11.5nA set H-SPEED ADC meas	-11.60000 nA	-11.50000 nA	-11.50000 nA	0.00000 nA	Pass
	-10nA set DVM meas	-10.10000 nA	-10.00000 nA	-9.94000 nA	0.00000 nA	Pass
	-10nA set H-RESOLN ADC meas	-10.10000 nA	-10.00000 nA	-9.98000 nA	0.00000 nA	Pass
	-10nA set H-SPEED ADC meas	-10.10000 nA	-10.00000 nA	-9.98000 nA	0.00000 nA	Pass
	-1nA set DVM meas	-1.01000 nA	-1.00000 nA	-0.98800 nA	0.00000 nA	Pass
	-1nA set H-RESOLN ADC meas	-1.03000 nA	-1.00000 nA	-0.97100 nA	0.00000 nA	Pass
	-1nA set H-SPEED ADC meas	-1.03000 nA	-1.00000 nA	-0.97100 nA	0.00000 nA	Pass
	1nA set DVM meas	0.98800 nA	1.00000 nA	1.01000 nA	0.00000 nA	Pass
	1nA set H-RESOLN ADC meas	0.97100 nA	1.00000 nA	1.03000 nA	0.00000 nA	Pass
	1nA set H-SPEED ADC meas	0.97100 nA	1.00000 nA	1.03000 nA	0.00000 nA	Pass
	10nA set DVM meas	9.94000 nA	10.00000 nA	10.10000 nA	0.00000 nA	Pass
	10nA set H-RESOLN ADC meas	9.98000 nA	10.00000 nA	10.10000 nA	0.00000 nA	Pass
	10nA set H-SPEED ADC meas	9.98000 nA	10.00000 nA	10.10000 nA	0.00000 nA	Pass
	11.5nA set DVM meas	11.40000 nA	11.50000 nA	11.60000 nA	0.00000 nA	Pass
	11.5nA set H-RESOLN ADC meas	11.50000 nA	11.50000 nA	11.60000 nA	0.00000 nA	Pass
	11.5nA set H-SPEED ADC meas	11.50000 nA	11.50000 nA	11.60000 nA	0.00000 nA	Pass
100nA range	-115nA set DVM meas	-115.00000 nA	-115.00000 nA	-115.00000 nA	0.00000 nA	Pass
	-115nA set H-RESOLN ADC meas	-115.00000 nA	-115.00000 nA	-115.00000 nA	0.00000 nA	Pass
	-115nA set H-SPEED ADC meas	-115.00000 nA	-115.00000 nA	-115.00000 nA	0.00000 nA	Pass
	-100nA set DVM meas	-100.00000 nA	-99.90000 nA	-99.80000 nA	0.00000 nA	Pass
	-100nA set H-RESOLN ADC meas	-100.00000 nA	-100.00000 nA	-99.80000 nA	0.00000 nA	Pass
	-100nA set H-SPEED ADC meas	-100.00000 nA	-100.00000 nA	-99.80000 nA	0.00000 nA	Pass
	-10nA set DVM meas	-10.10000 nA	-9.99000 nA	-9.94000 nA	0.00000 nA	Pass
	-10nA set H-RESOLN ADC meas	-10.00000 nA	-10.00000 nA	-9.95000 nA	0.00000 nA	Pass
	-10nA set H-SPEED ADC meas	-10.00000 nA	-10.00000 nA	-9.95000 nA	0.00000 nA	Pass
	10nA set DVM meas	9.94000 nA	9.99000 nA	10.10000 nA	0.00000 nA	Pass
	10nA set H-RESOLN ADC meas	9.95000 nA	10.00000 nA	10.00000 nA	0.00000 nA	Pass
	10nA set H-SPEED ADC meas	9.95000 nA	10.00000 nA	10.00000 nA	0.00000 nA	Pass
	100nA set DVM meas	99.80000 nA	99.90000 nA	100.00000 nA	0.00000 nA	Pass
	100nA set H-RESOLN ADC meas	99.80000 nA	100.00000 nA	100.00000 nA	0.00000 nA	Pass
	100nA set H-SPEED ADC meas	99.80000 nA	100.00000 nA	100.00000 nA	0.00000 nA	Pass
	115nA set DVM meas	115.00000 nA	115.00000 nA	115.00000 nA	0.00000 nA	Pass
	115nA set H-RESOLN ADC meas	115.00000 nA	115.00000 nA	115.00000 nA	0.00000 nA	Pass
	115nA set H-SPEED ADC meas	115.00000 nA	115.00000 nA	115.00000 nA	0.00000 nA	Pass

Figure 2-22 Agilent E5273A test record example (5/10)

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Slot 1		Minimum	Results	Maximum	Uncertainty	Pass/Fail
1uA range	-1.15uA set DVM meas	-1.15000 uA	-1.15000 uA	-1.15000 uA	0.00000 uA	Pass
	-1.15uA set H-RESOLN ADC meas	-1.15000 uA	-1.15000 uA	-1.15000 uA	0.00000 uA	Pass
	-1.15uA set H-SPEED ADC meas	-1.15000 uA	-1.15000 uA	-1.15000 uA	0.00000 uA	Pass
	-1uA set DVM meas	-1.00000 uA	-1.00000 uA	-0.99800 uA	0.00000 uA	Pass
	-1uA set H-RESOLN ADC meas	-1.00000 uA	-1.00000 uA	-0.99900 uA	0.00000 uA	Pass
	-1uA set H-SPEED ADC meas	-1.00000 uA	-1.00000 uA	-0.99900 uA	0.00000 uA	Pass
	-100nA set DVM meas	-101.00000 nA	-100.00000 nA	-99.50000 nA	0.00000 nA	Pass
	-100nA set H-RESOLN ADC meas	-100.00000 nA	-100.00000 nA	-99.70000 nA	0.00000 nA	Pass
	-100nA set H-SPEED ADC meas	-100.00000 nA	-100.00000 nA	-99.70000 nA	0.00000 nA	Pass
	100nA set DVM meas	99.50000 nA	100.00000 nA	101.00000 nA	0.00000 nA	Pass
	100nA set H-RESOLN ADC meas	99.70000 nA	100.00000 nA	100.00000 nA	0.00000 nA	Pass
	100nA set H-SPEED ADC meas	99.70000 nA	100.00000 nA	100.00000 nA	0.00000 nA	Pass
	1uA set DVM meas	0.99800 uA	1.00000 uA	1.00000 uA	0.00000 uA	Pass
	1uA set H-RESOLN ADC meas	0.99900 uA	1.00000 uA	1.00000 uA	0.00000 uA	Pass
	1uA set H-SPEED ADC meas	0.99900 uA	1.00000 uA	1.00000 uA	0.00000 uA	Pass
	1.15uA set DVM meas	1.15000 uA	1.15000 uA	1.15000 uA	0.00000 uA	Pass
	1.15uA set H-RESOLN ADC meas	1.15000 uA	1.15000 uA	1.15000 uA	0.00000 uA	Pass
	1.15uA set H-SPEED ADC meas	1.15000 uA	1.15000 uA	1.15000 uA	0.00000 uA	Pass
10uA range	-11.5uA set DVM meas	-11.50000 uA	-11.50000 uA	-11.50000 uA	0.00000 uA	Pass
	-11.5uA set H-RESOLN ADC meas	-11.50000 uA	-11.50000 uA	-11.50000 uA	0.00000 uA	Pass
	-11.5uA set H-SPEED ADC meas	-11.50000 uA	-11.50000 uA	-11.50000 uA	0.00000 uA	Pass
	-10uA set DVM meas	-10.01700 uA	-10.00000 uA	-9.98300 uA	0.00000 uA	Pass
	-10uA set H-RESOLN ADC meas	-10.00000 uA	-10.00000 uA	-9.99000 uA	0.00000 uA	Pass
	-10uA set H-SPEED ADC meas	-10.00000 uA	-10.00100 uA	-9.99000 uA	0.00000 uA	Pass
	-1uA set DVM meas	-1.01000 uA	-1.00000 uA	-0.99400 uA	0.00000 uA	Pass
	-1uA set H-RESOLN ADC meas	-1.00000 uA	-1.00000 uA	-0.99600 uA	0.00000 uA	Pass
	-1uA set H-SPEED ADC meas	-1.00000 uA	-1.00000 uA	-0.99600 uA	0.00000 uA	Pass
	1uA set DVM meas	0.99400 uA	1.00000 uA	1.01000 uA	0.00000 uA	Pass
	1uA set H-RESOLN ADC meas	0.99600 uA	1.00000 uA	1.00000 uA	0.00000 uA	Pass
	1uA set H-SPEED ADC meas	0.99600 uA	1.00000 uA	1.00000 uA	0.00000 uA	Pass
	10uA set DVM meas	9.98300 uA	10.00000 uA	10.01700 uA	0.00000 uA	Pass
	10uA set H-RESOLN ADC meas	9.99000 uA	10.00000 uA	10.00000 uA	0.00000 uA	Pass
	10uA set H-SPEED ADC meas	9.99000 uA	10.00000 uA	10.00000 uA	0.00000 uA	Pass
	11.5uA set DVM meas	11.50000 uA	11.50000 uA	11.50000 uA	0.00000 uA	Pass
	11.5uA set H-RESOLN ADC meas	11.50000 uA	11.50000 uA	11.50000 uA	0.00000 uA	Pass
	11.5uA set H-SPEED ADC meas	11.50000 uA	11.50000 uA	11.50000 uA	0.00000 uA	Pass
100uA range	-115uA set DVM meas	-115.17800 uA	-115.00800 uA	-114.82200 uA	0.00000 uA	Pass
	-115uA set H-RESOLN ADC meas	-115.14300 uA	-115.01500 uA	-114.87300 uA	0.00000 uA	Pass
	-115uA set H-SPEED ADC meas	-115.14300 uA	-115.01500 uA	-114.87300 uA	0.00000 uA	Pass
	-100uA set DVM meas	-100.16000 uA	-100.00300 uA	-99.84000 uA	0.00000 uA	Pass
	-100uA set H-RESOLN ADC meas	-100.12300 uA	-100.01000 uA	-99.90000 uA	0.00000 uA	Pass
	-100uA set H-SPEED ADC meas	-100.12300 uA	-100.01000 uA	-99.90000 uA	0.00000 uA	Pass
	-10uA set DVM meas	-10.05200 uA	-10.00000 uA	-9.94800 uA	0.00000 uA	Pass
	-10uA set H-RESOLN ADC meas	-10.00000 uA	-10.00000 uA	-9.97000 uA	0.00000 uA	Pass
	-10uA set H-SPEED ADC meas	-10.00000 uA	-10.00000 uA	-9.97000 uA	0.00000 uA	Pass
	10uA set DVM meas	9.94800 uA	10.00000 uA	10.05200 uA	0.00000 uA	Pass
	10uA set H-RESOLN ADC meas	9.97000 uA	10.00000 uA	10.00000 uA	0.00000 uA	Pass
	10uA set H-SPEED ADC meas	9.97000 uA	10.00000 uA	10.00000 uA	0.00000 uA	Pass
	100uA set DVM meas	99.84000 uA	100.00000 uA	100.16000 uA	0.00000 uA	Pass
	100uA set H-RESOLN ADC meas	99.90000 uA	100.01000 uA	100.11900 uA	0.00000 uA	Pass
	100uA set H-SPEED ADC meas	99.90000 uA	100.01000 uA	100.11900 uA	0.00000 uA	Pass
	115uA set DVM meas	114.82200 uA	115.00400 uA	115.17800 uA	0.00000 uA	Pass
	115uA set H-RESOLN ADC meas	114.86900 uA	115.01000 uA	115.13900 uA	0.00000 uA	Pass
	115uA set H-SPEED ADC meas	114.86900 uA	115.01000 uA	115.13900 uA	0.00000 uA	Pass
1mA range	-1.15mA set DVM meas	-1.15188 mA	-1.15005 mA	-1.14812 mA	0.00000 mA	Pass
	-1.15mA set H-RESOLN ADC meas	-1.15150 mA	-1.15015 mA	-1.14860 mA	0.00000 mA	Pass
	-1.15mA set H-SPEED ADC meas	-1.15150 mA	-1.15015 mA	-1.14860 mA	0.00000 mA	Pass
	-1mA set DVM meas	-1.00170 mA	-0.99998 mA	-0.99830 mA	0.00000 mA	Pass
	-1mA set H-RESOLN ADC meas	-1.00128 mA	-1.00010 mA	-0.99868 mA	0.00000 mA	Pass
	-1mA set H-SPEED ADC meas	-1.00128 mA	-1.00010 mA	-0.99868 mA	0.00000 mA	Pass
	-100uA set DVM meas	-100.62000 uA	-100.00000 uA	-99.38000 uA	0.00000 uA	Pass
	-100uA set H-RESOLN ADC meas	-100.38900 uA	-100.00000 uA	-99.60000 uA	0.00000 uA	Pass
	-100uA set H-SPEED ADC meas	-100.38900 uA	-100.00000 uA	-99.60000 uA	0.00000 uA	Pass
	100uA set DVM meas	99.38000 uA	100.02800 uA	100.62000 uA	0.00000 uA	Pass
	100uA set H-RESOLN ADC meas	99.60000 uA	100.00000 uA	100.42800 uA	0.00000 uA	Pass
	100uA set H-SPEED ADC meas	99.60000 uA	100.00000 uA	100.42800 uA	0.00000 uA	Pass
	1mA set DVM meas	0.99830 mA	1.00005 mA	1.00170 mA	0.00000 mA	Pass
	1mA set H-RESOLN ADC meas	0.99875 mA	1.00010 mA	1.00135 mA	0.00000 mA	Pass
	1mA set H-SPEED ADC meas	0.99875 mA	1.00010 mA	1.00135 mA	0.00000 mA	Pass
	1.15mA set DVM meas	1.14812 mA	1.15008 mA	1.15188 mA	0.00000 mA	Pass
	1.15mA set H-RESOLN ADC meas	1.14863 mA	1.15015 mA	1.15153 mA	0.00000 mA	Pass

Figure 2-23 Agilent E5273A test record example (6/10)

Slot 1		Minimum	Results	Maximum	Uncertainty	Pass/Fail
10mA range	-11.5mA set DVM meas	-11.51780 mA	-11.50104 mA	-11.48220 mA	0.00000 mA	Pass
	-11.5mA set H-RESOLN ADC meas	-11.51454 mA	-11.50100 mA	-11.48754 mA	0.00000 mA	Pass
	-11.5mA set H-SPEED ADC meas	-11.51454 mA	-11.50150 mA	-11.48754 mA	0.00000 mA	Pass
	-10mA set DVM meas	-10.01600 mA	-10.00031 mA	-9.98400 mA	0.00000 mA	Pass
	-10mA set H-RESOLN ADC meas	-10.01231 mA	-10.00050 mA	-9.98831 mA	0.00000 mA	Pass
	-10mA set H-SPEED ADC meas	-10.01231 mA	-10.00050 mA	-9.98831 mA	0.00000 mA	Pass
	-1mA set DVM meas	-1.00520 mA	-0.99998 mA	-0.99480 mA	0.00000 mA	Pass
	-1mA set H-RESOLN ADC meas	-1.00298 mA	-1.00000 mA	-0.99698 mA	0.00000 mA	Pass
	-1mA set H-SPEED ADC meas	-1.00298 mA	-1.00000 mA	-0.99698 mA	0.00000 mA	Pass
	1mA set DVM meas	0.99480 mA	0.99988 mA	1.00520 mA	0.00000 mA	Pass
	1mA set H-RESOLN ADC meas	0.99688 mA	1.00000 mA	1.00288 mA	0.00000 mA	Pass
	1mA set H-SPEED ADC meas	0.99688 mA	1.00000 mA	1.00288 mA	0.00000 mA	Pass
	10mA set DVM meas	9.98400 mA	10.00023 mA	10.01600 mA	0.00000 mA	Pass
	10mA set H-RESOLN ADC meas	9.98823 mA	10.00100 mA	10.01223 mA	0.00000 mA	Pass
	10mA set H-SPEED ADC meas	9.98823 mA	10.00050 mA	10.01223 mA	0.00000 mA	Pass
	11.5mA set DVM meas	11.48220 mA	11.50053 mA	11.51780 mA	0.00000 mA	Pass
	11.5mA set H-RESOLN ADC meas	11.48703 mA	11.50100 mA	11.51403 mA	0.00000 mA	Pass
	11.5mA set H-SPEED ADC meas	11.48703 mA	11.50100 mA	11.51403 mA	0.00000 mA	Pass
100mA range	-115mA set DVM meas	-115.18800 mA	-115.01072 mA	-114.81200 mA	0.00000 mA	Pass
	-115mA set H-RESOLN ADC meas	-115.15572 mA	-115.01000 mA	-114.86572 mA	0.00000 mA	Pass
	-115mA set H-SPEED ADC meas	-115.15572 mA	-115.01500 mA	-114.86572 mA	0.00000 mA	Pass
	-100mA set DVM meas	-100.17000 mA	-100.00725 mA	-99.83000 mA	0.00000 mA	Pass
	-100mA set H-RESOLN ADC meas	-100.13725 mA	-100.01000 mA	-99.87725 mA	0.00000 mA	Pass
	-100mA set H-SPEED ADC meas	-100.13725 mA	-100.01000 mA	-99.87725 mA	0.00000 mA	Pass
	-10mA set DVM meas	-10.06200 mA	-9.99974 mA	-9.93800 mA	0.00000 mA	Pass
	-10mA set H-RESOLN ADC meas	-10.03974 mA	-10.00000 mA	-9.95974 mA	0.00000 mA	Pass
	-10mA set H-SPEED ADC meas	-10.03974 mA	-10.00000 mA	-9.95974 mA	0.00000 mA	Pass
	10mA set DVM meas	9.93800 mA	10.00230 mA	10.06200 mA	0.00000 mA	Pass
	10mA set H-RESOLN ADC meas	9.96230 mA	10.00000 mA	10.04230 mA	0.00000 mA	Pass
	10mA set H-SPEED ADC meas	9.96230 mA	10.00000 mA	10.04230 mA	0.00000 mA	Pass
	100mA set DVM meas	99.83000 mA	100.00774 mA	100.17000 mA	0.00000 mA	Pass
	100mA set H-RESOLN ADC meas	99.87774 mA	100.01000 mA	100.13774 mA	0.00000 mA	Pass
	100mA set H-SPEED ADC meas	99.87774 mA	100.01000 mA	100.13774 mA	0.00000 mA	Pass
	115mA set DVM meas	114.81200 mA	115.01484 mA	115.18800 mA	0.00000 mA	Pass
	115mA set H-RESOLN ADC meas	114.86984 mA	115.02000 mA	115.15984 mA	0.00000 mA	Pass
	115mA set H-SPEED ADC meas	114.86984 mA	115.02000 mA	115.15984 mA	0.00000 mA	Pass
200mA range	-200mA set DVM meas	-200.34000 mA	-200.00594 mA	-199.66000 mA	0.00000 mA	Pass
	-200mA set H-RESOLN ADC meas	-200.26594 mA	-200.01000 mA	-199.74594 mA	0.00000 mA	Pass
	-200mA set H-SPEED ADC meas	-200.26594 mA	-200.02000 mA	-199.74594 mA	0.00000 mA	Pass
	-20mA set DVM meas	-20.12400 mA	-20.00628 mA	-19.87600 mA	0.00000 mA	Pass
	-20mA set H-RESOLN ADC meas	-20.08628 mA	-20.01000 mA	-19.92628 mA	0.00000 mA	Pass
	-20mA set H-SPEED ADC meas	-20.08628 mA	-20.01000 mA	-19.92628 mA	0.00000 mA	Pass
	20mA set DVM meas	19.87600 mA	19.99608 mA	20.12400 mA	0.00000 mA	Pass
	20mA set H-RESOLN ADC meas	19.91608 mA	20.00000 mA	20.07608 mA	0.00000 mA	Pass
	20mA set H-SPEED ADC meas	19.91608 mA	20.00000 mA	20.07608 mA	0.00000 mA	Pass
	200mA set DVM meas	199.66000 mA	199.99038 mA	200.34000 mA	0.00000 mA	Pass
	200mA set H-RESOLN ADC meas	199.73038 mA	200.02000 mA	200.25038 mA	0.00000 mA	Pass
	200mA set H-SPEED ADC meas	199.73038 mA	200.01000 mA	200.25038 mA	0.00000 mA	Pass

SMU CMR Test

Slot 1		Minimum	Results	Maximum		Pass/Fail
	CMR meas	-4.00000 uA	0.00000 uA	4.00000 uA		Pass

Figure 2-24 Agilent E5273A test record example (7/10)

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HPSMU Accuracy Test

SMU voltage Test

Slot 2		Minimum	Results	Maximum	Uncertainty	Pass/Fail
2V range	-2.2V set DVM meas	-2.20466 V	-2.20016 V	-2.19534 V	0.00000 V	Pass
	-2.2V set H-RESOLN ADC meas	-2.20130 V	-2.20030 V	-2.19902 V	0.00000 V	Pass
	-2.2V set H-SPEED ADC meas	-2.20152 V	-2.20040 V	-2.19880 V	0.00000 V	Pass
	-2V set DVM meas	-2.00150 V	-2.00002 V	-1.99850 V	0.00000 V	Pass
	-2V set H-RESOLN ADC meas	-2.00112 V	-2.00010 V	-1.99892 V	0.00000 V	Pass
	-2V set H-SPEED ADC meas	-2.00132 V	-2.00010 V	-1.99872 V	0.00000 V	Pass
	0V set DVM meas	-900.00000 uV	1.28000 uV	900.00000 uV	0.00000 uV	Pass
	0V set H-RESOLN ADC meas	-698.72300 uV	0.00000 uV	701.27700 uV	0.00000 uV	Pass
	0V set H-SPEED ADC meas	-698.72300 uV	0.00000 uV	701.27700 uV	0.00000 uV	Pass
	2V set DVM meas	1.99850 V	1.99995 V	2.00150 V	0.00000 V	Pass
	2V set H-RESOLN ADC meas	1.99885 V	2.00010 V	2.00105 V	0.00000 V	Pass
	2V set H-SPEED ADC meas	1.99865 V	2.00010 V	2.00125 V	0.00000 V	Pass
	2.2V set DVM meas	2.19534 V	2.19956 V	2.20466 V	0.00000 V	Pass
	2.2V set H-RESOLN ADC meas	2.19842 V	2.19970 V	2.20070 V	0.00000 V	Pass
	2.2V set H-SPEED ADC meas	2.19820 V	2.19970 V	2.20092 V	0.00000 V	Pass
20V range	-22V set DVM meas	-22.01360 V	-21.99963 V	-21.98640 V	0.00000 V	Pass
	-22V set H-RESOLN ADC meas	-22.00603 V	-22.00300 V	-21.99323 V	0.00000 V	Pass
	-22V set H-SPEED ADC meas	-22.01023 V	-22.00200 V	-21.98903 V	0.00000 V	Pass
	-20V set DVM meas	-20.01000 V	-20.00024 V	-19.99000 V	0.00000 V	Pass
	-20V set H-RESOLN ADC meas	-20.00624 V	-20.00200 V	-19.99424 V	0.00000 V	Pass
	-20V set H-SPEED ADC meas	-20.01024 V	-20.00200 V	-19.99024 V	0.00000 V	Pass
	0V set DVM meas	-4.00000 mV	-0.36972 mV	4.00000 mV	0.00000 mV	Pass
	0V set H-RESOLN ADC meas	-2.36972 mV	0.00000 mV	1.63028 mV	0.00000 mV	Pass
	0V set H-SPEED ADC meas	-4.36972 mV	-1.00000 mV	3.63028 mV	0.00000 mV	Pass
	20V set DVM meas	19.99000 V	19.99971 V	20.01000 V	0.00000 V	Pass
	20V set H-RESOLN ADC meas	19.99371 V	20.00100 V	20.00571 V	0.00000 V	Pass
	20V set H-SPEED ADC meas	19.98971 V	20.00100 V	20.00971 V	0.00000 V	Pass
	22V set DVM meas	21.98640 V	21.99968 V	22.01360 V	0.00000 V	Pass
	22V set H-RESOLN ADC meas	21.99328 V	22.00200 V	22.00608 V	0.00000 V	Pass
	22V set H-SPEED ADC meas	21.98908 V	22.00200 V	22.01028 V	0.00000 V	Pass
40V range	-44V set DVM meas	-44.03260 V	-44.00213 V	-43.96740 V	0.00000 V	Pass
	-44V set H-RESOLN ADC meas	-44.01393 V	-44.00800 V	-43.99033 V	0.00000 V	Pass
	-44V set H-SPEED ADC meas	-44.02333 V	-44.00800 V	-43.98093 V	0.00000 V	Pass
	-40V set DVM meas	-40.01900 V	-39.99812 V	-39.98100 V	0.00000 V	Pass
	-40V set H-RESOLN ADC meas	-40.00912 V	-40.00400 V	-39.98712 V	0.00000 V	Pass
	-40V set H-SPEED ADC meas	-40.01812 V	-40.00400 V	-39.97812 V	0.00000 V	Pass
	0V set DVM meas	-7.00000 mV	-0.56365 mV	7.00000 mV	0.00000 mV	Pass
	0V set H-RESOLN ADC meas	-3.56365 mV	0.00000 mV	2.43635 mV	0.00000 mV	Pass
	0V set H-SPEED ADC meas	-8.56365 mV	0.00000 mV	7.43635 mV	0.00000 mV	Pass
	40V set DVM meas	39.98100 V	39.99875 V	40.01900 V	0.00000 V	Pass
	40V set H-RESOLN ADC meas	39.98775 V	40.00400 V	40.00975 V	0.00000 V	Pass
	40V set H-SPEED ADC meas	39.97875 V	40.00400 V	40.01875 V	0.00000 V	Pass
	44V set DVM meas	43.96740 V	43.99914 V	44.03260 V	0.00000 V	Pass
	44V set H-RESOLN ADC meas	43.98734 V	44.00400 V	44.01094 V	0.00000 V	Pass
	44V set H-SPEED ADC meas	43.97794 V	44.00600 V	44.02034 V	0.00000 V	Pass
100V range	-110V set DVM meas	-110.07950 V	-109.98967 V	-109.92050 V	0.00000 V	Pass
	-110V set H-RESOLN ADC meas	-110.02767 V	-110.01000 V	-109.95167 V	0.00000 V	Pass
	-110V set H-SPEED ADC meas	-110.04267 V	-110.00500 V	-109.93667 V	0.00000 V	Pass
	-100V set DVM meas	-100.05500 V	-99.99941 V	-99.94500 V	0.00000 V	Pass
	-100V set H-RESOLN ADC meas	-100.03441 V	-100.01000 V	-99.96441 V	0.00000 V	Pass
	-100V set H-SPEED ADC meas	-100.04941 V	-100.01000 V	-99.94941 V	0.00000 V	Pass
	0V set DVM meas	-15.00000 mV	0.43986 mV	15.00000 mV	0.00000 mV	Pass
	0V set H-RESOLN ADC meas	-4.56014 mV	0.00000 mV	5.43986 mV	0.00000 mV	Pass
	0V set H-SPEED ADC meas	-19.56014 mV	0.00000 mV	20.43986 mV	0.00000 mV	Pass
	100V set DVM meas	99.94500 V	99.99762 V	100.05500 V	0.00000 V	Pass
	100V set H-RESOLN ADC meas	99.96262 V	100.01000 V	100.03262 V	0.00000 V	Pass
	100V set H-SPEED ADC meas	99.94762 V	100.01000 V	100.04762 V	0.00000 V	Pass
	110V set DVM meas	109.92050 V	109.99321 V	110.07950 V	0.00000 V	Pass
	110V set H-RESOLN ADC meas	109.95521 V	110.00500 V	110.03121 V	0.00000 V	Pass
	110V set H-SPEED ADC meas	109.94021 V	110.00500 V	110.04621 V	0.00000 V	Pass
200V range	-200V set DVM meas	-200.12000 V	-199.97961 V	-199.88000 V	0.00000 V	Pass
	-200V set H-RESOLN ADC meas	-200.05961 V	-200.01000 V	-199.89961 V	0.00000 V	Pass
	-200V set H-SPEED ADC meas	-200.08961 V	-200.00000 V	-199.86961 V	0.00000 V	Pass
	0V set DVM meas	-30.00000 mV	-0.49305 mV	30.00000 mV	0.00000 mV	Pass
	0V set H-RESOLN ADC meas	-10.49305 mV	0.00000 mV	9.50695 mV	0.00000 mV	Pass
	0V set H-SPEED ADC meas	-40.49305 mV	0.00000 mV	39.50695 mV	0.00000 mV	Pass
	200V set DVM meas	199.88000 V	199.97968 V	200.12000 V	0.00000 V	Pass
	200V set H-RESOLN ADC meas	199.89968 V	200.00000 V	200.05968 V	0.00000 V	Pass

Figure 2-25 Agilent E5273A test record example (8/10)

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SMU current Test

Slot 2		Minimum	Results	Maximum	Uncertainty	Pass/Fail
pre-test 100nA range	-115nA set Offset V	-1.00000 mV	-0.01580 mV	1.00000 mV		Pass
	-100nA set Offset V	-1.00000 mV	-0.01370 mV	1.00000 mV		Pass
	-10nA set Offset V	-1.00000 mV	-0.01070 mV	1.00000 mV		Pass
	10nA set Offset V	-1.00000 mV	-0.01110 mV	1.00000 mV		Pass
	100nA set Offset V	-1.00000 mV	-0.00919 mV	1.00000 mV		Pass
	115nA set Offset V	-1.00000 mV	-0.00837 mV	1.00000 mV		Pass
pre-test 1uA range	-1.15uA set Offset V	-1.00000 mV	-0.04110 mV	1.00000 mV		Pass
	-1uA set Offset V	-1.00000 mV	-0.03650 mV	1.00000 mV		Pass
	-100nA set Offset V	-1.00000 mV	-0.01410 mV	1.00000 mV		Pass
	100nA set Offset V	-1.00000 mV	-0.00955 mV	1.00000 mV		Pass
	1uA set Offset V	-1.00000 mV	0.01500 mV	1.00000 mV		Pass
	1.15uA set Offset V	-1.00000 mV	0.02130 mV	1.00000 mV		Pass
1nA range	-1.15nA set DVM meas	-1.16000 nA	-1.15000 nA	-1.14000 nA	0.00000 nA	Pass
	-1.15nA set H-RESOLN ADC meas	-1.16000 nA	-1.15000 nA	-1.14000 nA	0.00000 nA	Pass
	-1.15nA set H-SPEED ADC meas	-1.16000 nA	-1.15000 nA	-1.14000 nA	0.00000 nA	Pass
	-1nA set DVM meas	-1.01000 nA	-0.99800 nA	-0.99200 nA	0.00000 nA	Pass
	-1nA set H-RESOLN ADC meas	-1.01000 nA	-1.00000 nA	-0.99000 nA	0.00000 nA	Pass
	-1nA set H-SPEED ADC meas	-1.01000 nA	-1.00000 nA	-0.99000 nA	0.00000 nA	Pass
	-100pA set DVM meas	-104.00000 pA	-99.80000 pA	-96.50000 pA	0.00000 pA	Pass
	-100pA set H-RESOLN ADC meas	-103.00000 pA	-100.00000 pA	-96.30000 pA	0.00000 pA	Pass
	-100pA set H-SPEED ADC meas	-103.00000 pA	-100.00000 pA	-96.30000 pA	0.00000 pA	Pass
	100pA set DVM meas	96.50000 pA	99.80000 pA	104.00000 pA	0.00000 pA	Pass
	100pA set H-RESOLN ADC meas	96.30000 pA	100.00000 pA	103.00000 pA	0.00000 pA	Pass
	100pA set H-SPEED ADC meas	96.30000 pA	100.00000 pA	103.00000 pA	0.00000 pA	Pass
	1nA set DVM meas	0.99200 nA	0.99800 nA	1.01000 nA	0.00000 nA	Pass
	1nA set H-RESOLN ADC meas	0.99000 nA	1.00000 nA	1.01000 nA	0.00000 nA	Pass
	1nA set H-SPEED ADC meas	0.99000 nA	1.00000 nA	1.01000 nA	0.00000 nA	Pass
	1.15nA set DVM meas	1.14000 nA	1.15000 nA	1.16000 nA	0.00000 nA	Pass
	1.15nA set H-RESOLN ADC meas	1.14000 nA	1.15000 nA	1.16000 nA	0.00000 nA	Pass
	1.15nA set H-SPEED ADC meas	1.14000 nA	1.15000 nA	1.16000 nA	0.00000 nA	Pass
10nA range	-11.5nA set DVM meas	-11.60000 nA	-11.50000 nA	-11.40000 nA	0.00000 nA	Pass
	-11.5nA set H-RESOLN ADC meas	-11.50000 nA	-11.50000 nA	-11.50000 nA	0.00000 nA	Pass
	-11.5nA set H-SPEED ADC meas	-11.50000 nA	-11.50000 nA	-11.50000 nA	0.00000 nA	Pass
	-10nA set DVM meas	-10.10000 nA	-10.00000 nA	-9.94000 nA	0.00000 nA	Pass
	-10nA set H-RESOLN ADC meas	-10.00000 nA	-10.00000 nA	-9.96000 nA	0.00000 nA	Pass
	-10nA set H-SPEED ADC meas	-10.00000 nA	-10.00000 nA	-9.96000 nA	0.00000 nA	Pass
	-1nA set DVM meas	-1.01000 nA	-0.99700 nA	-0.98800 nA	0.00000 nA	Pass
	-1nA set H-RESOLN ADC meas	-1.03000 nA	-1.00000 nA	-0.96600 nA	0.00000 nA	Pass
	-1nA set H-SPEED ADC meas	-1.03000 nA	-1.00000 nA	-0.96600 nA	0.00000 nA	Pass
	1nA set DVM meas	0.98800 nA	1.00000 nA	1.01000 nA	0.00000 nA	Pass
	1nA set H-RESOLN ADC meas	0.97000 nA	1.00000 nA	1.03000 nA	0.00000 nA	Pass
	1nA set H-SPEED ADC meas	0.97000 nA	1.00000 nA	1.03000 nA	0.00000 nA	Pass
	10nA set DVM meas	9.94000 nA	10.00000 nA	10.10000 nA	0.00000 nA	Pass
	10nA set H-RESOLN ADC meas	9.96000 nA	10.00000 nA	10.00000 nA	0.00000 nA	Pass
	10nA set H-SPEED ADC meas	9.96000 nA	10.00000 nA	10.00000 nA	0.00000 nA	Pass
	11.5nA set DVM meas	11.40000 nA	11.50000 nA	11.60000 nA	0.00000 nA	Pass
	11.5nA set H-RESOLN ADC meas	11.50000 nA	11.50000 nA	11.50000 nA	0.00000 nA	Pass
	11.5nA set H-SPEED ADC meas	11.50000 nA	11.50000 nA	11.50000 nA	0.00000 nA	Pass
100nA range	-115nA set DVM meas	-115.00000 nA	-115.00000 nA	-115.00000 nA	0.00000 nA	Pass
	-115nA set H-RESOLN ADC meas	-115.00000 nA	-115.00000 nA	-115.00000 nA	0.00000 nA	Pass
	-115nA set H-SPEED ADC meas	-115.00000 nA	-115.00000 nA	-115.00000 nA	0.00000 nA	Pass
	-100nA set DVM meas	-100.00000 nA	-99.90000 nA	-99.80000 nA	0.00000 nA	Pass
	-100nA set H-RESOLN ADC meas	-100.00000 nA	-100.00000 nA	-99.80000 nA	0.00000 nA	Pass
	-100nA set H-SPEED ADC meas	-100.00000 nA	-100.00000 nA	-99.80000 nA	0.00000 nA	Pass
	-10nA set DVM meas	-10.10000 nA	-10.00000 nA	-9.94000 nA	0.00000 nA	Pass
	-10nA set H-RESOLN ADC meas	-10.00000 nA	-10.00000 nA	-9.96000 nA	0.00000 nA	Pass
	-10nA set H-SPEED ADC meas	-10.00000 nA	-10.00000 nA	-9.96000 nA	0.00000 nA	Pass
	10nA set DVM meas	9.94000 nA	10.00000 nA	10.10000 nA	0.00000 nA	Pass
	10nA set H-RESOLN ADC meas	9.96000 nA	10.00000 nA	10.00000 nA	0.00000 nA	Pass
	10nA set H-SPEED ADC meas	9.96000 nA	10.00000 nA	10.00000 nA	0.00000 nA	Pass
	100nA set DVM meas	99.80000 nA	99.90000 nA	100.00000 nA	0.00000 nA	Pass
	100nA set H-RESOLN ADC meas	99.80000 nA	100.00000 nA	100.00000 nA	0.00000 nA	Pass
	100nA set H-SPEED ADC meas	99.80000 nA	100.00000 nA	100.00000 nA	0.00000 nA	Pass
	115nA set DVM meas	115.00000 nA	115.00000 nA	115.00000 nA	0.00000 nA	Pass
	115nA set H-RESOLN ADC meas	115.00000 nA	115.00000 nA	115.00000 nA	0.00000 nA	Pass
	115nA set H-SPEED ADC meas	115.00000 nA	115.00000 nA	115.00000 nA	0.00000 nA	Pass

Figure 2-26 Agilent E5273A test record example (9/10)

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Slot 2		Minimum	Results	Maximum	Uncertainty	Pass/Fail
1uA range	-1.15uA set DVM meas	-1.15000 uA	-1.15000 uA	-1.15000 uA	0.00000 uA	Pass
	-1.15uA set H-RESOLN ADC meas	-1.15000 uA	-1.15000 uA	-1.15000 uA	0.00000 uA	Pass
	-1.15uA set H-SPEED ADC meas	-1.15000 uA	-1.15000 uA	-1.15000 uA	0.00000 uA	Pass
	-1uA set DVM meas	-1.00000 uA	-1.00000 uA	-0.99800 uA	0.00000 uA	Pass
	-1uA set H-RESOLN ADC meas	-1.00000 uA	-1.00000 uA	-0.99900 uA	0.00000 uA	Pass
	-1uA set H-SPEED ADC meas	-1.00000 uA	-1.00000 uA	-0.99900 uA	0.00000 uA	Pass
	-100nA set DVM meas	-101.00000 nA	-100.00000 nA	-99.50000 nA	0.00000 nA	Pass
	-100nA set H-RESOLN ADC meas	-100.00000 nA	-100.00000 nA	-99.70000 nA	0.00000 nA	Pass
	-100nA set H-SPEED ADC meas	-100.00000 nA	-100.00000 nA	-99.70000 nA	0.00000 nA	Pass
	100nA set DVM meas	99.50000 nA	100.00000 nA	101.00000 nA	0.00000 nA	Pass
	100nA set H-RESOLN ADC meas	99.70000 nA	100.00000 nA	100.00000 nA	0.00000 nA	Pass
	100nA set H-SPEED ADC meas	99.70000 nA	100.00000 nA	100.00000 nA	0.00000 nA	Pass
	1uA set DVM meas	0.99800 uA	1.00000 uA	1.00000 uA	0.00000 uA	Pass
	1uA set H-RESOLN ADC meas	0.99900 uA	1.00000 uA	1.00000 uA	0.00000 uA	Pass
	1uA set H-SPEED ADC meas	0.99900 uA	1.00000 uA	1.00000 uA	0.00000 uA	Pass
	1.15uA set DVM meas	1.15000 uA	1.15000 uA	1.15000 uA	0.00000 uA	Pass
	1.15uA set H-RESOLN ADC meas	1.15000 uA	1.15000 uA	1.15000 uA	0.00000 uA	Pass
	1.15uA set H-SPEED ADC meas	1.15000 uA	1.15000 uA	1.15000 uA	0.00000 uA	Pass
10uA range	-11.5uA set DVM meas	-11.50000 uA	-11.50000 uA	-11.50000 uA	0.00000 uA	Pass
	-11.5uA set H-RESOLN ADC meas	-11.50000 uA	-11.50200 uA	-11.50000 uA	0.00000 uA	Pass
	-11.5uA set H-SPEED ADC meas	-11.50000 uA	-11.50200 uA	-11.50000 uA	0.00000 uA	Pass
	-10uA set DVM meas	-10.01700 uA	-10.00000 uA	-9.98300 uA	0.00000 uA	Pass
	-10uA set H-RESOLN ADC meas	-10.00000 uA	-10.00100 uA	-9.99000 uA	0.00000 uA	Pass
	-10uA set H-SPEED ADC meas	-10.00000 uA	-10.00100 uA	-9.99000 uA	0.00000 uA	Pass
	-1uA set DVM meas	-1.01000 uA	-1.00000 uA	-0.99400 uA	0.00000 uA	Pass
	-1uA set H-RESOLN ADC meas	-1.00000 uA	-1.00000 uA	-0.99600 uA	0.00000 uA	Pass
	-1uA set H-SPEED ADC meas	-1.00000 uA	-1.00000 uA	-0.99600 uA	0.00000 uA	Pass
	1uA set DVM meas	0.99400 uA	1.00000 uA	1.01000 uA	0.00000 uA	Pass
	1uA set H-RESOLN ADC meas	0.99600 uA	1.00000 uA	1.00000 uA	0.00000 uA	Pass
	1uA set H-SPEED ADC meas	0.99600 uA	1.00000 uA	1.00000 uA	0.00000 uA	Pass
	10uA set DVM meas	9.98300 uA	10.00000 uA	10.01700 uA	0.00000 uA	Pass
	10uA set H-RESOLN ADC meas	9.99000 uA	10.00000 uA	10.00000 uA	0.00000 uA	Pass
	10uA set H-SPEED ADC meas	9.99000 uA	10.00000 uA	10.00000 uA	0.00000 uA	Pass
	11.5uA set DVM meas	11.50000 uA	11.50000 uA	11.50000 uA	0.00000 uA	Pass
	11.5uA set H-RESOLN ADC meas	11.50000 uA	11.50000 uA	11.50000 uA	0.00000 uA	Pass
	11.5uA set H-SPEED ADC meas	11.50000 uA	11.50000 uA	11.50000 uA	0.00000 uA	Pass
100uA range	-115uA set DVM meas	-115.17800 uA	-115.00900 uA	-114.82200 uA	0.00000 uA	Pass
	-115uA set H-RESOLN ADC meas	-115.14400 uA	-115.01500 uA	-114.87400 uA	0.00000 uA	Pass
	-115uA set H-SPEED ADC meas	-115.14400 uA	-115.01500 uA	-114.87400 uA	0.00000 uA	Pass
	-100uA set DVM meas	-100.16000 uA	-100.00000 uA	-99.84000 uA	0.00000 uA	Pass
	-100uA set H-RESOLN ADC meas	-100.12000 uA	-100.00500 uA	-99.90000 uA	0.00000 uA	Pass
	-100uA set H-SPEED ADC meas	-100.12000 uA	-100.00500 uA	-99.90000 uA	0.00000 uA	Pass
	-10uA set DVM meas	-10.05200 uA	-10.00000 uA	-9.94800 uA	0.00000 uA	Pass
	-10uA set H-RESOLN ADC meas	-10.00000 uA	-10.00500 uA	-9.97000 uA	0.00000 uA	Pass
	-10uA set H-SPEED ADC meas	-10.00000 uA	-10.00500 uA	-9.97000 uA	0.00000 uA	Pass
	10uA set DVM meas	9.94800 uA	10.00000 uA	10.05200 uA	0.00000 uA	Pass
	10uA set H-RESOLN ADC meas	9.97000 uA	10.00500 uA	10.00000 uA	0.00000 uA	Pass
	10uA set H-SPEED ADC meas	9.97000 uA	10.00500 uA	10.00000 uA	0.00000 uA	Pass
	100uA set DVM meas	99.84000 uA	100.00000 uA	100.16000 uA	0.00000 uA	Pass
	100uA set H-RESOLN ADC meas	99.90000 uA	100.00500 uA	100.11900 uA	0.00000 uA	Pass
	100uA set H-SPEED ADC meas	99.90000 uA	100.00500 uA	100.11900 uA	0.00000 uA	Pass
	115uA set DVM meas	114.82200 uA	115.00700 uA	115.17800 uA	0.00000 uA	Pass
	115uA set H-RESOLN ADC meas	114.87200 uA	115.01500 uA	115.14200 uA	0.00000 uA	Pass
	115uA set H-SPEED ADC meas	114.87200 uA	115.01500 uA	115.14200 uA	0.00000 uA	Pass
1mA range	-1.15mA set DVM meas	-1.15188 mA	-1.15007 mA	-1.14812 mA	0.00000 mA	Pass
	-1.15mA set H-RESOLN ADC meas	-1.15152 mA	-1.15015 mA	-1.14862 mA	0.00000 mA	Pass
	-1.15mA set H-SPEED ADC meas	-1.15152 mA	-1.15015 mA	-1.14862 mA	0.00000 mA	Pass
	-1mA set DVM meas	-1.00170 mA	-1.00006 mA	-0.99830 mA	0.00000 mA	Pass
	-1mA set H-RESOLN ADC meas	-1.00136 mA	-1.00015 mA	-0.99876 mA	0.00000 mA	Pass
	-1mA set H-SPEED ADC meas	-1.00136 mA	-1.00015 mA	-0.99876 mA	0.00000 mA	Pass
	-100uA set DVM meas	-100.62000 uA	-100.03000 uA	-99.38000 uA	0.00000 uA	Pass
	-100uA set H-RESOLN ADC meas	-100.43000 uA	-100.05000 uA	-99.60000 uA	0.00000 uA	Pass
	-100uA set H-SPEED ADC meas	-100.43000 uA	-100.05000 uA	-99.60000 uA	0.00000 uA	Pass
	100uA set DVM meas	99.38000 uA	100.00000 uA	100.62000 uA	0.00000 uA	Pass
	100uA set H-RESOLN ADC meas	99.60000 uA	100.00000 uA	100.40000 uA	0.00000 uA	Pass
	100uA set H-SPEED ADC meas	99.60000 uA	100.00000 uA	100.40000 uA	0.00000 uA	Pass
	1mA set DVM meas	0.99830 mA	1.00001 mA	1.00170 mA	0.00000 mA	Pass
	1mA set H-RESOLN ADC meas	0.99871 mA	1.00010 mA	1.00131 mA	0.00000 mA	Pass
	1mA set H-SPEED ADC meas	0.99871 mA	1.00010 mA	1.00131 mA	0.00000 mA	Pass
	1.15mA set DVM meas	1.14812 mA	1.15002 mA	1.15188 mA	0.00000 mA	Pass
	1.15mA set H-RESOLN ADC meas	1.14857 mA	1.15010 mA	1.15147 mA	0.00000 mA	Pass

Figure 2-27 Agilent E5273A test record example (10/10)

Slot 2		Minimum	Results	Maximum	Uncertainty	Pass/Fail
10mA range	-11.5mA set DVM meas	-11.51780 mA	-11.50126 mA	-11.48220 mA	0.00000 mA	Pass
	-11.5mA set H-RESOLN ADC meas	-11.51476 mA	-11.50100 mA	-11.48776 mA	0.00000 mA	Pass
	-11.5mA set H-SPEED ADC meas	-11.51476 mA	-11.50100 mA	-11.48776 mA	0.00000 mA	Pass
	-10mA set DVM meas	-10.01600 mA	-10.00060 mA	-9.98400 mA	0.00000 mA	Pass
	-10mA set H-RESOLN ADC meas	-10.01260 mA	-10.00050 mA	-9.98860 mA	0.00000 mA	Pass
	-10mA set H-SPEED ADC meas	-10.01260 mA	-10.00050 mA	-9.98860 mA	0.00000 mA	Pass
	-1mA set DVM meas	-1.00520 mA	-1.00004 mA	-0.99480 mA	0.00000 mA	Pass
	-1mA set H-RESOLN ADC meas	-1.00304 mA	-1.00050 mA	-0.99704 mA	0.00000 mA	Pass
	-1mA set H-SPEED ADC meas	-1.00304 mA	-1.00050 mA	-0.99704 mA	0.00000 mA	Pass
	1mA set DVM meas	0.99480 mA	1.00006 mA	1.00520 mA	0.00000 mA	Pass
	1mA set H-RESOLN ADC meas	0.99706 mA	1.00000 mA	1.00306 mA	0.00000 mA	Pass
	1mA set H-SPEED ADC meas	0.99706 mA	1.00000 mA	1.00306 mA	0.00000 mA	Pass
	10mA set DVM meas	9.98400 mA	10.00065 mA	10.01600 mA	0.00000 mA	Pass
	10mA set H-RESOLN ADC meas	9.98865 mA	10.00100 mA	10.01265 mA	0.00000 mA	Pass
	10mA set H-SPEED ADC meas	9.98865 mA	10.00100 mA	10.01265 mA	0.00000 mA	Pass
	11.5mA set DVM meas	11.48220 mA	11.50122 mA	11.51780 mA	0.00000 mA	Pass
	11.5mA set H-RESOLN ADC meas	11.48772 mA	11.50150 mA	11.51472 mA	0.00000 mA	Pass
	11.5mA set H-SPEED ADC meas	11.48772 mA	11.50150 mA	11.51472 mA	0.00000 mA	Pass
100mA range	-115mA set DVM meas	-115.18800 mA	-115.00845 mA	-114.81200 mA	0.00000 mA	Pass
	-115mA set H-RESOLN ADC meas	-115.15345 mA	-115.02000 mA	-114.86345 mA	0.00000 mA	Pass
	-115mA set H-SPEED ADC meas	-115.15345 mA	-115.02000 mA	-114.86345 mA	0.00000 mA	Pass
	-100mA set DVM meas	-100.17000 mA	-100.00009 mA	-99.83000 mA	0.00000 mA	Pass
	-100mA set H-RESOLN ADC meas	-100.13009 mA	-100.01000 mA	-99.87009 mA	0.00000 mA	Pass
	-100mA set H-SPEED ADC meas	-100.13009 mA	-100.01000 mA	-99.87009 mA	0.00000 mA	Pass
	-10mA set DVM meas	-10.06200 mA	-10.00449 mA	-9.93800 mA	0.00000 mA	Pass
	-10mA set H-RESOLN ADC meas	-10.04449 mA	-10.01000 mA	-9.96449 mA	0.00000 mA	Pass
	-10mA set H-SPEED ADC meas	-10.04449 mA	-10.01000 mA	-9.96449 mA	0.00000 mA	Pass
	10mA set DVM meas	9.93800 mA	10.00404 mA	10.06200 mA	0.00000 mA	Pass
	10mA set H-RESOLN ADC meas	9.96404 mA	10.00500 mA	10.04404 mA	0.00000 mA	Pass
	10mA set H-SPEED ADC meas	9.96404 mA	10.00500 mA	10.04404 mA	0.00000 mA	Pass
	100mA set DVM meas	99.83000 mA	100.00143 mA	100.17000 mA	0.00000 mA	Pass
	100mA set H-RESOLN ADC meas	99.87143 mA	100.00500 mA	100.13143 mA	0.00000 mA	Pass
	100mA set H-SPEED ADC meas	99.87143 mA	100.00500 mA	100.13143 mA	0.00000 mA	Pass
	115mA set DVM meas	114.81200 mA	115.00675 mA	115.18800 mA	0.00000 mA	Pass
	115mA set H-RESOLN ADC meas	114.86175 mA	115.01500 mA	115.15175 mA	0.00000 mA	Pass
	115mA set H-SPEED ADC meas	114.86175 mA	115.01500 mA	115.15175 mA	0.00000 mA	Pass
1A range	-1A set DVM meas	-1.00550 A	-0.99998 A	-0.99450 A	0.00000 A	Pass
	-1A set H-RESOLN ADC meas	-1.00528 A	-1.00010 A	-0.99468 A	0.00000 A	Pass
	-1A set H-SPEED ADC meas	-1.00528 A	-1.00010 A	-0.99468 A	0.00000 A	Pass
	-100mA set DVM meas	-101.00000 mA	-100.05400 mA	-99.00000 mA	0.00000 mA	Pass
	-100mA set H-RESOLN ADC meas	-100.85400 mA	-100.10000 mA	-99.25400 mA	0.00000 mA	Pass
	-100mA set H-SPEED ADC meas	-100.85400 mA	-100.10000 mA	-99.25400 mA	0.00000 mA	Pass
	100mA set DVM meas	99.00000 mA	100.03863 mA	101.00000 mA	0.00000 mA	Pass
	100mA set H-RESOLN ADC meas	99.23863 mA	100.05000 mA	100.83863 mA	0.00000 mA	Pass
	100mA set H-SPEED ADC meas	99.23863 mA	100.05000 mA	100.83863 mA	0.00000 mA	Pass
	1A set DVM meas	0.99450 A	0.99999 A	1.00550 A	0.00000 A	Pass
	1A set H-RESOLN ADC meas	0.99469 A	1.00010 A	1.00529 A	0.00000 A	Pass
	1A set H-SPEED ADC meas	0.99469 A	1.00010 A	1.00529 A	0.00000 A	Pass

SMU CMR Test

Slot 2		Minimum	Results	Maximum		Pass/Fail
	CMR meas	-4.00000 uA	0.50000 uA	4.00000 uA		Pass

3 Troubleshooting

This chapter describes the Agilent E5270A/E5272A/E5273A troubleshooting procedures and the reference information, and consists of the following sections.

- “Introduction”
- “Main Troubleshooting Flow”
- “Power Supply Failure”
- “Miscellaneous Failure”
- “Self-test Failure”
- “SMU and GNDU/ADC Module Failure”
- “PV Failure”
- “Troubleshooting Reference”

WARNING **The information in this manual is provided for use by service trained personnel only. To avoid electrical shock, do not perform any procedures in this manual unless you are qualified to do so.**

Potential shock hazard. Dangerous voltage may be present on the board assembly (including shield cover) for up to 10 seconds after you set the Line switch to off.

- **Power supply module: maximum; ±300 V**
- **Other modules: maximum; ±270 V**

CAUTION Before you start the troubleshooting, check if there is no object found in and around the fans and the cooling air holes. If found, remove them.

Before you access the inside of the instrument, make sure the power is turned off.

Introduction

Troubleshooting tools

The troubleshooting in this chapter is performed by using the following tools:

- Built-in selftest and diagnostics
- Performance verification (PV) software

When you use the above tools, you may also perform the following to isolate the problem.

- Disconnect the connection between two assemblies, then perform the test.
- Remove an assembly, then perform the test.
- Swap on SMU module with another SMU module, then perform the test.
- Remove the power supply, and turn on the power supply only.

After repair

If you replace a module or a board, execute the performance verification. See Chapter 5 for the details.

Notes for troubleshooting

- Before an assembly replacement, try to reconnect the cable or reinstall the assembly to check the connections. Sometimes bad connections cause problems.
- Before you start the troubleshooting, confirm the GPIB address, line frequency, and the firmware revision, so that you can set them properly when the troubleshooting is done.
- The only difference between the E5272A and E5273A is the SMU module configuration. When the power is turned on, the SMU module ID is checked and if both of the two SMUs are recognized as MPSMU, the instrument is identified as E5272A. And if MPSMU is recognized at the slot 1 and HPSMSU is recognized at the slot 2, the instrument is identified as E5273A.

CAUTION Do not block the ventilation opening on the side covers. Otherwise, thermal damage might occur.

Notes on the modules and the boards in the E5270A/E5272A/E5273A

Power supply module

- The power supply module can operate by the ac voltage 90 V - 260 V without any manual switching.
- Each dc output line has the detection circuit for over load, over voltage, and under voltage. If any abnormal condition is detected, the power supply module shutdowns by itself.
- The power supply module detects the fan revolution speed. If the power supply fan slows down or stops, the power supply module detects it.
- There is no serviceable part inside the power supply module. Don't open and access the inside.
- The cable that connects the power supply module with the motherboard is set as a part of the power supply module replaceable part.
- The fuse is located inside of the power supply module and it is accessible from outside of the module.

Frame fan

- The frame fan's revolution is monitored by the CPU board. So, if the fans slow down or stop, it is detected as an error and the shutdown occurs. It takes about 10 seconds before the shutdown occurs.
- If the fans are connected to wrong connectors, the shutdown occurs as the CPU board detects the error.

LCD backlight

- LED array is used to provide the power to LCD backlight. So, there is no high voltage used.

GNDU/ADC module

- If there are failures in ADC tests, the self-tests for SMU will not be performed. However, if there are failures in GNDU, still the self-tests for SMU will be performed. If there are failures in ADC tests, the self-tests for SMU will not be performed. However, if there are failures in GNDU, still the self-tests for SMU will be performed. If the self-test for GNDU/ADC fails, the output relay will stay open, but still GNDU output is connected to chassis common via the 11 k
- If the self-test for GNDU/ADC fails, the output relay will stay open, but still GNDU output is connected to the chassis common via the 11 kΩ resistor.

CPU module

- If CPU module has the error that CPU module can still give an error code, the self-test for GNDU/ADC module and the SMU module will be executed.
- If CPU module is installed but if any other modules or boards are not installed properly, the CPU module gives the following errors.

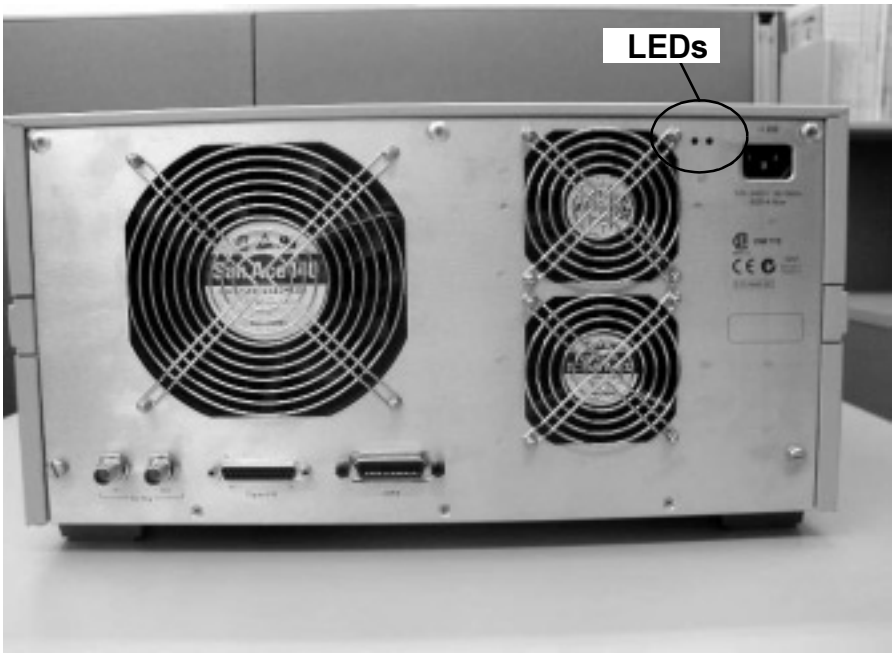
Table 3-1

Not-installed module or board	Error code
Front board	716: CPU failed LCD read/write test.
GNDU/ADC module	720: high resolution ADC is not installed.

Rear panel LED error indicators

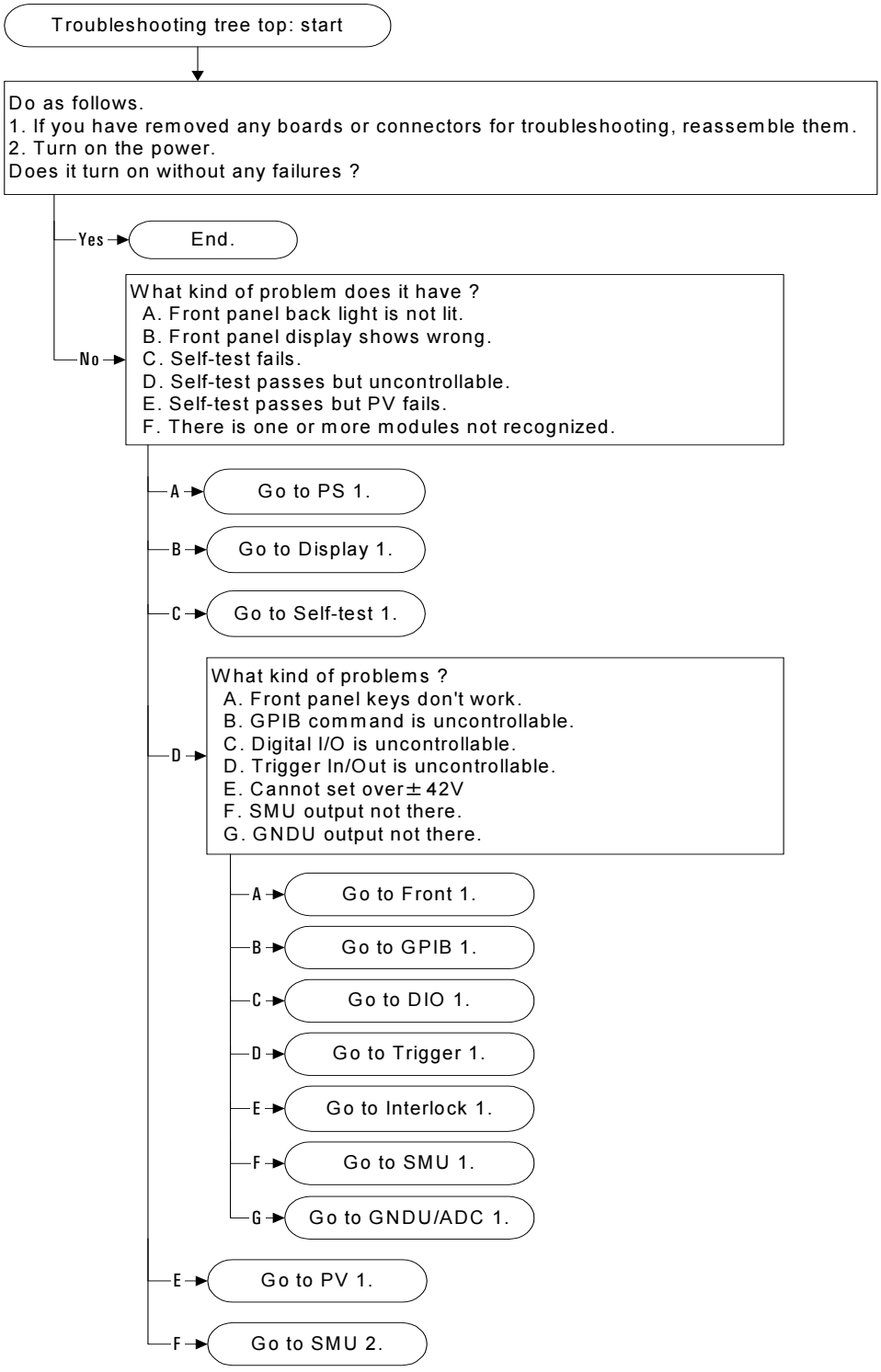
In the troubleshooting process, you may need to refer to the two LED error indicators on the instrument rear panel. Below picture show you the location of the LEDs.

Figure 3-1 Rear panel LED error indicators



Main Troubleshooting Flow

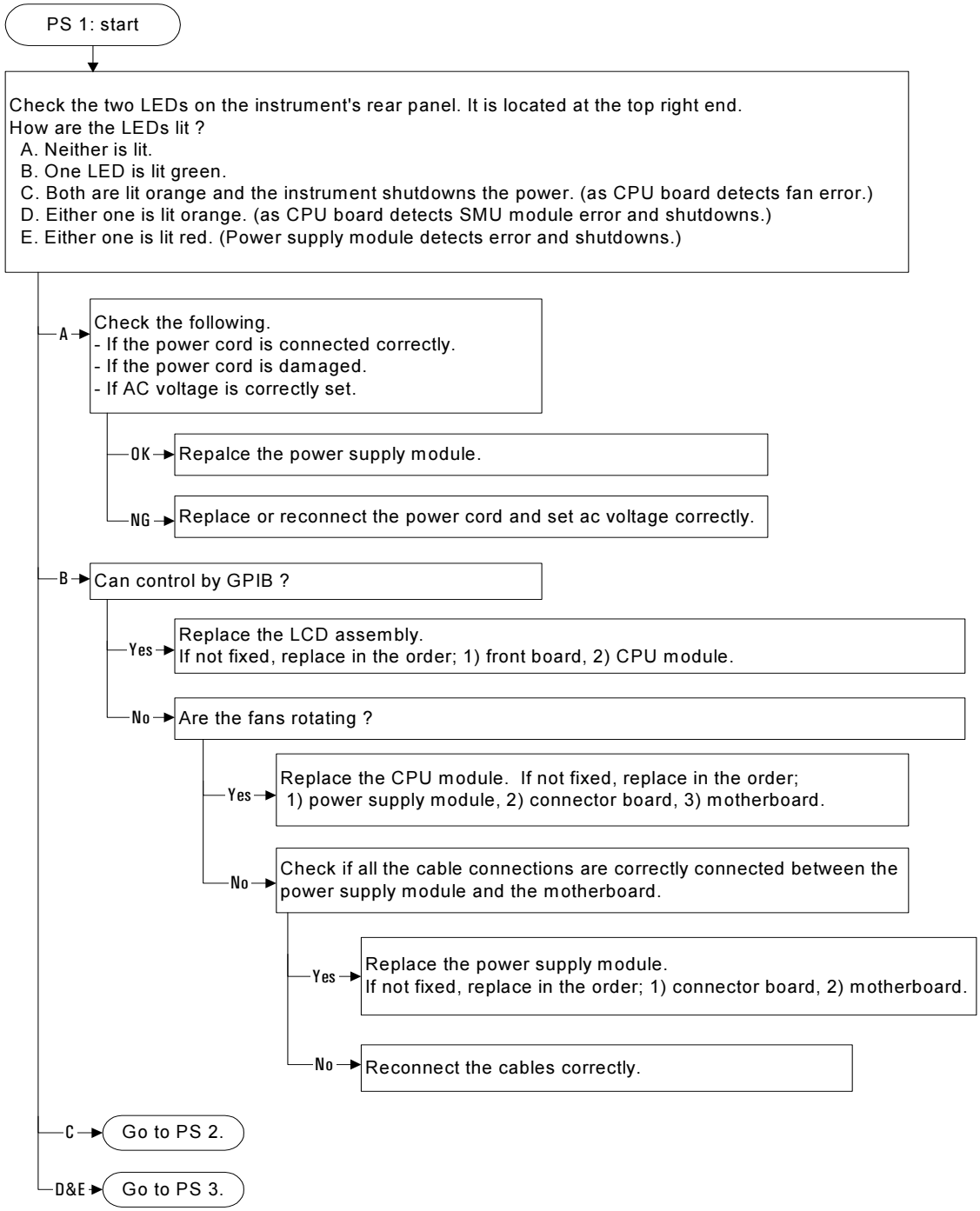
Figure 3-2 Main troubleshooting flow (1 of 1)



Power Supply Failure

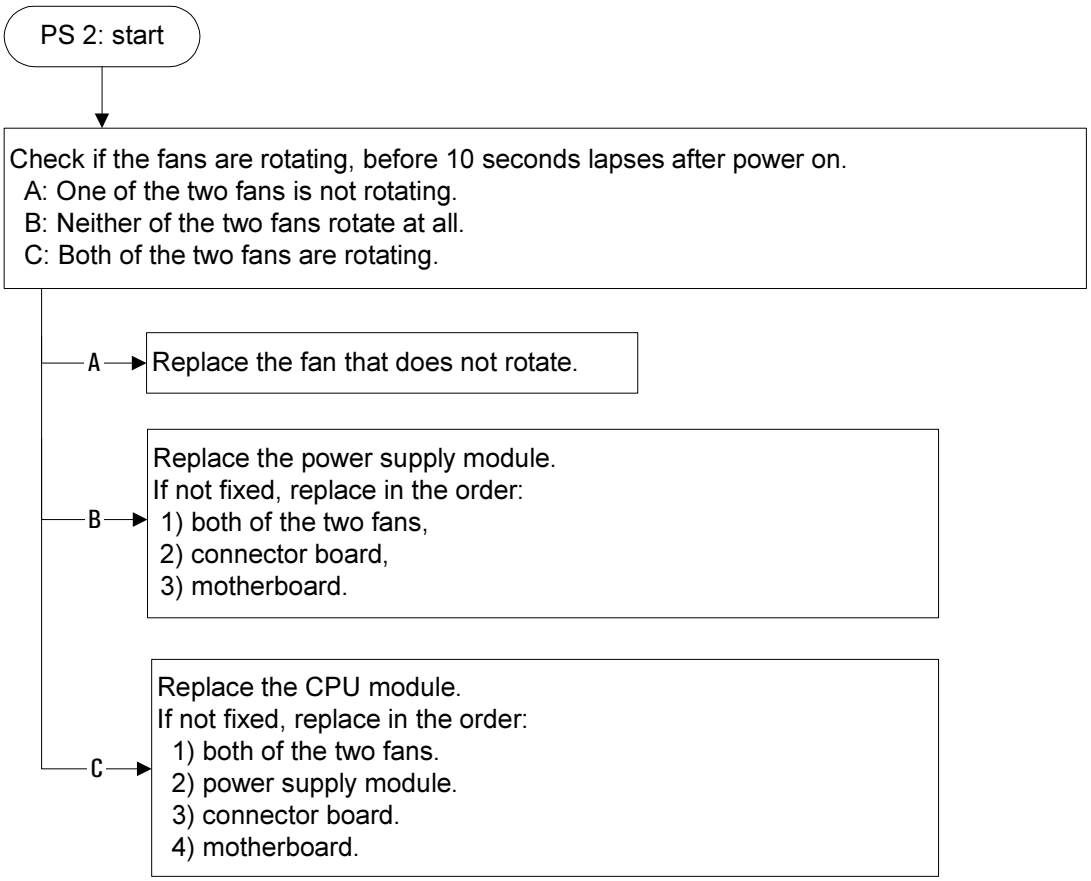
If front display panel back light is not lit

Figure 3-3 Power supply troubleshooting flow (1 of 4)



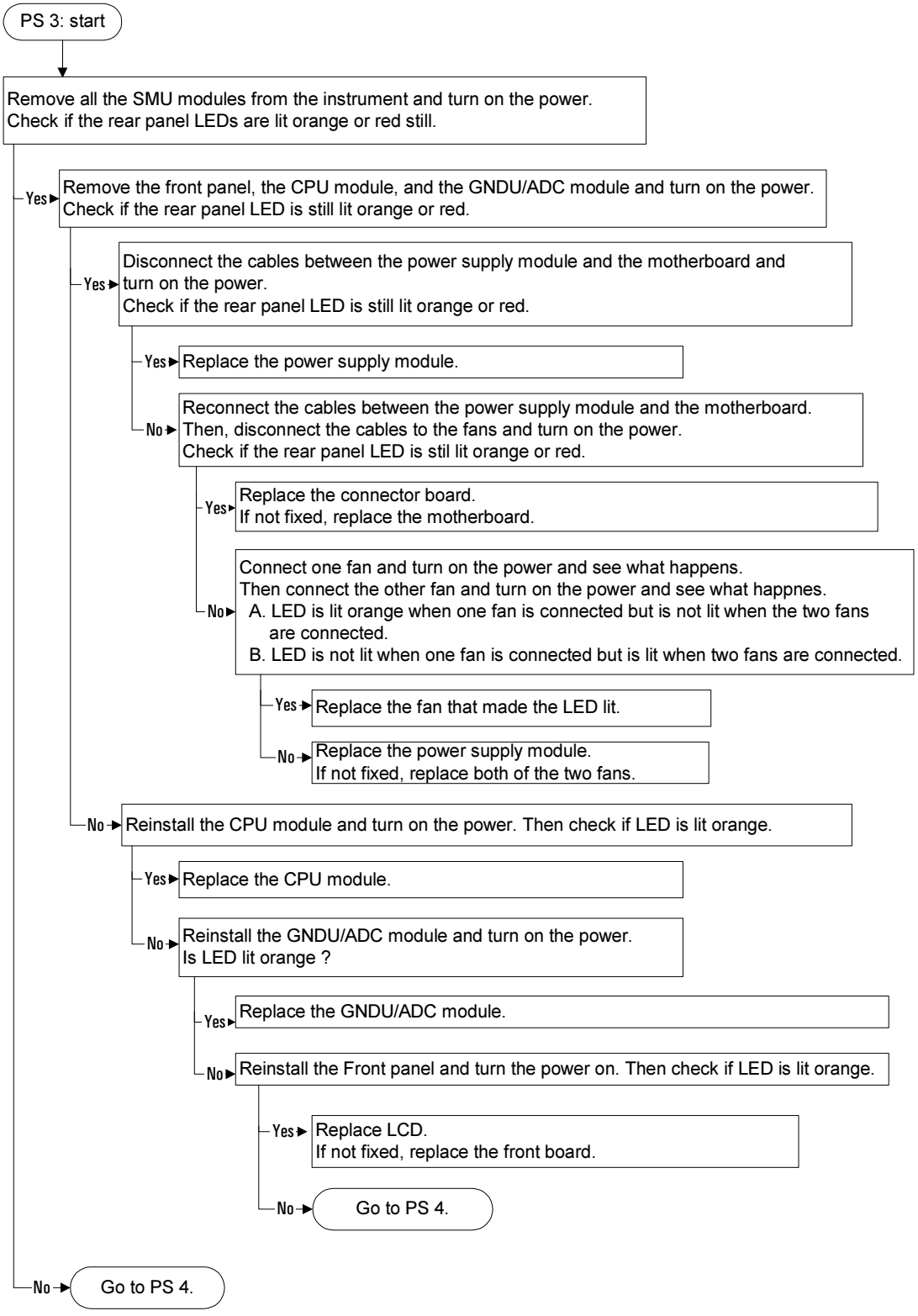
If both of the LEDs on the rear panel are lit orange

Figure 3-4 Power supply troubleshooting flow (2 of 4)



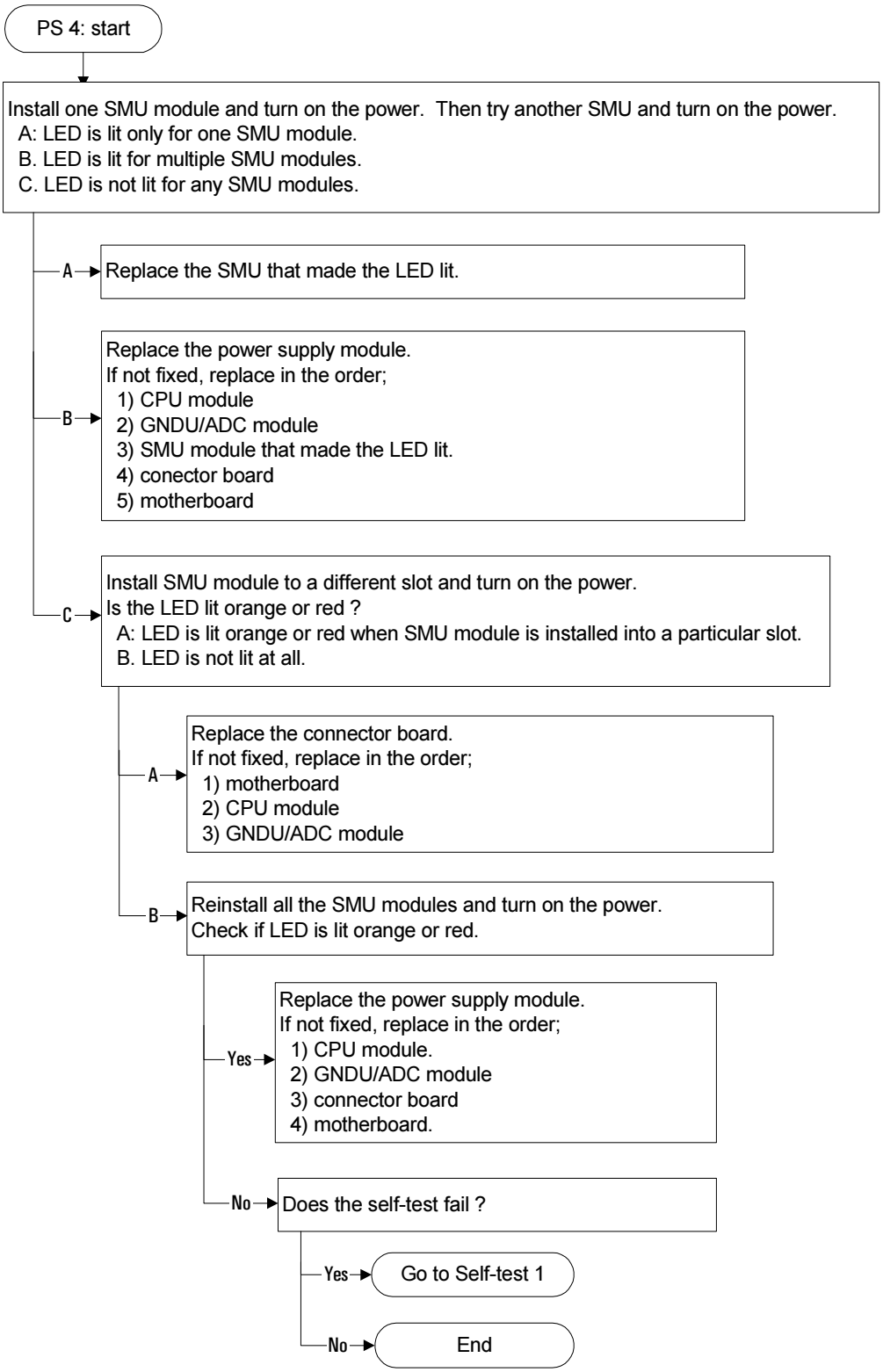
If one of the LEDs on the rear panel is lit orange or red

Figure 3-5 Power supply troubleshooting flow (3 of 4)



If one of the rear panel LED is lit orange or red when SMU module is installed.

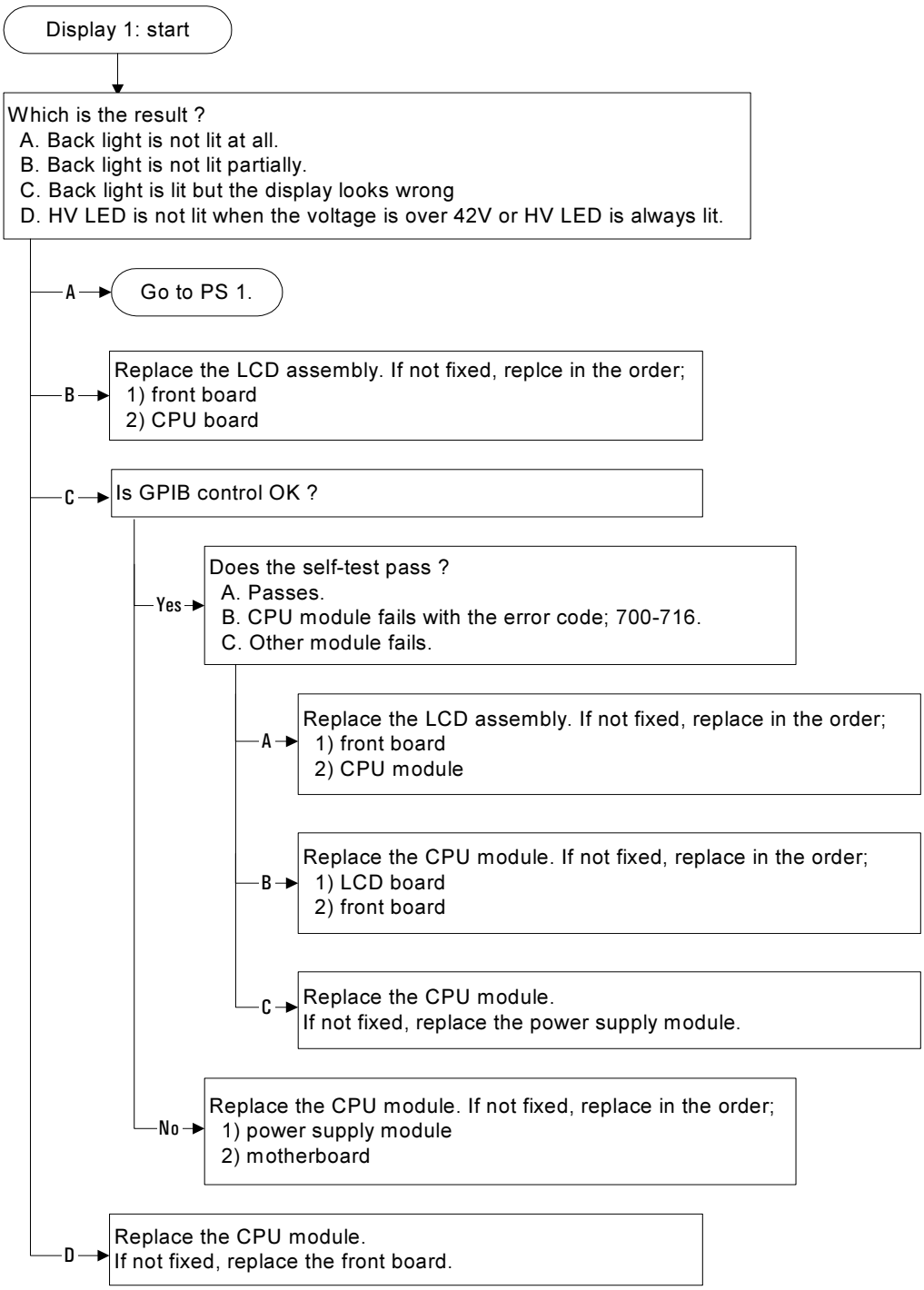
Figure 3-6 Power supply troubleshooting flow (4 of 4)



Miscellaneous Failure

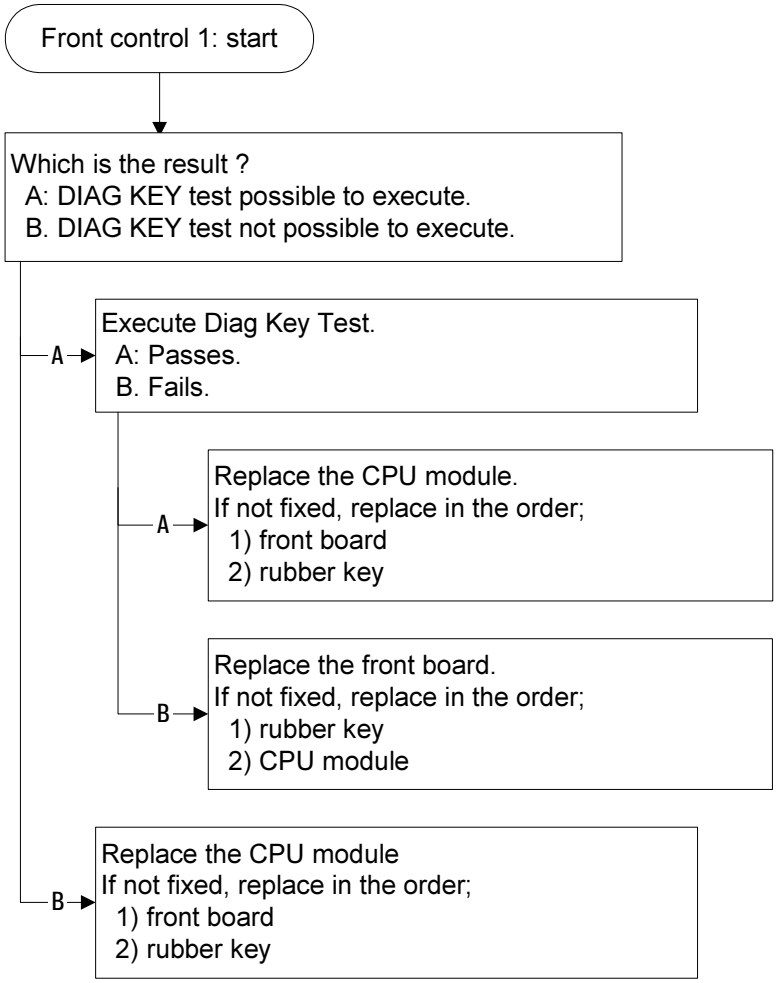
If front display looks wrong or back light is not lit

Figure 3-7 Front display troubleshooting flow



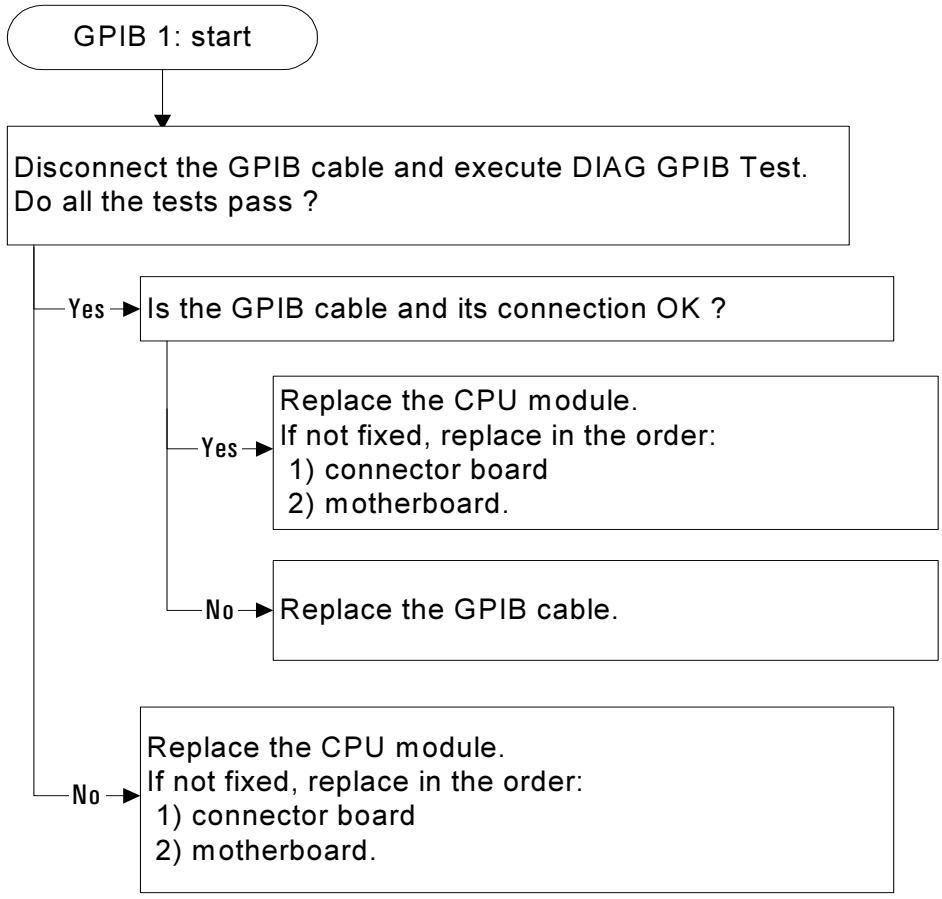
If the front panel keys do not work

Figure 3-8 Front control board troubleshooting flow



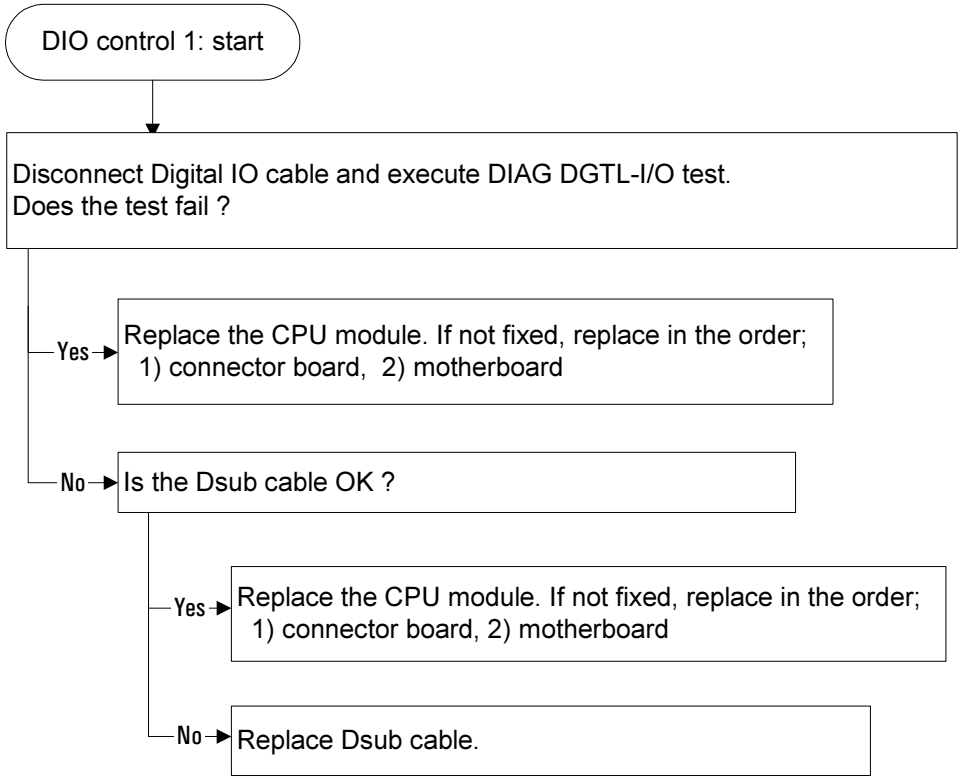
If GPIB control fails

Figure 3-9 GPIB troubleshooting flow



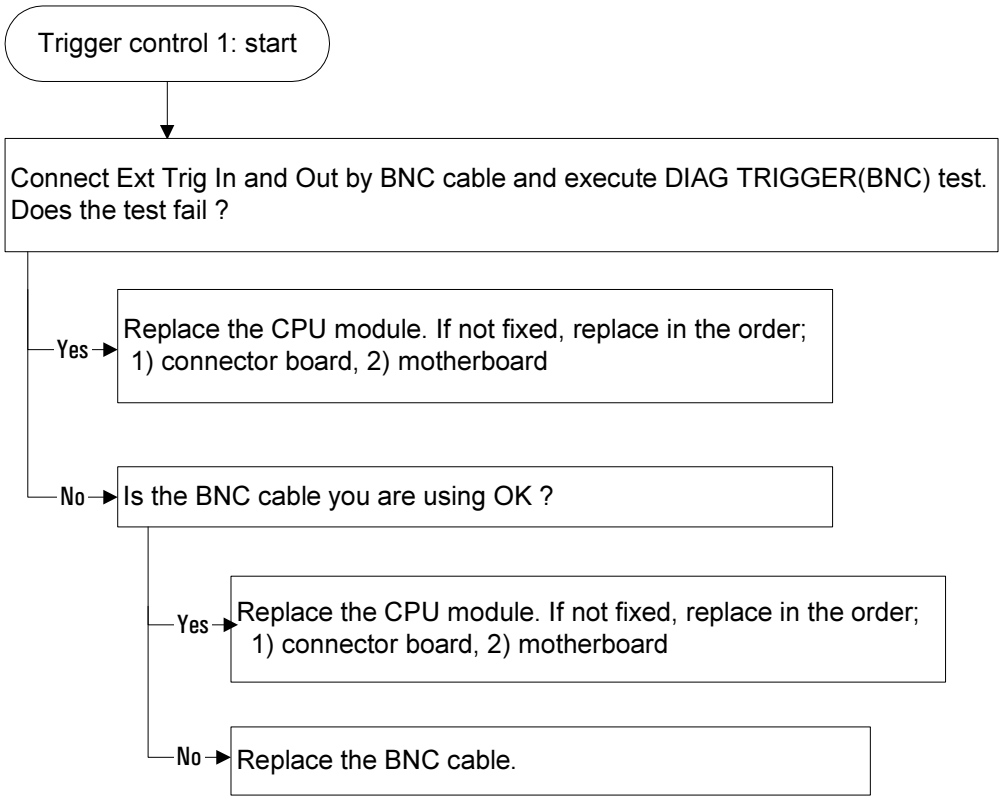
If digital I/O control fails

Figure 3-10 Digital I/O control troubleshooting flow



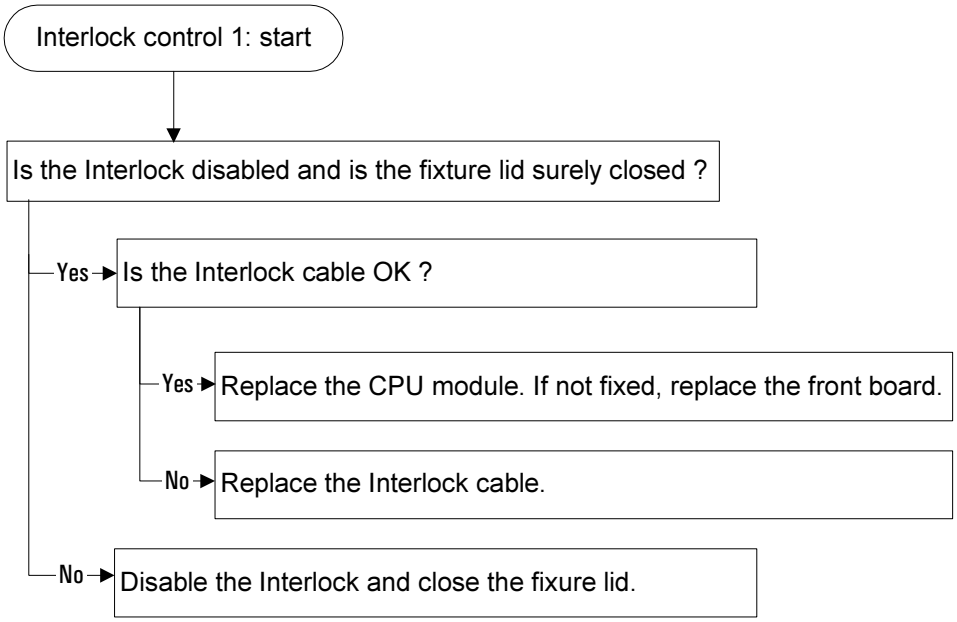
If trigger control fails but the self-test passes

Figure 3-11 Trigger control troubleshooting flow



If interlock control fail (Voltage over 42 V cannot be output)

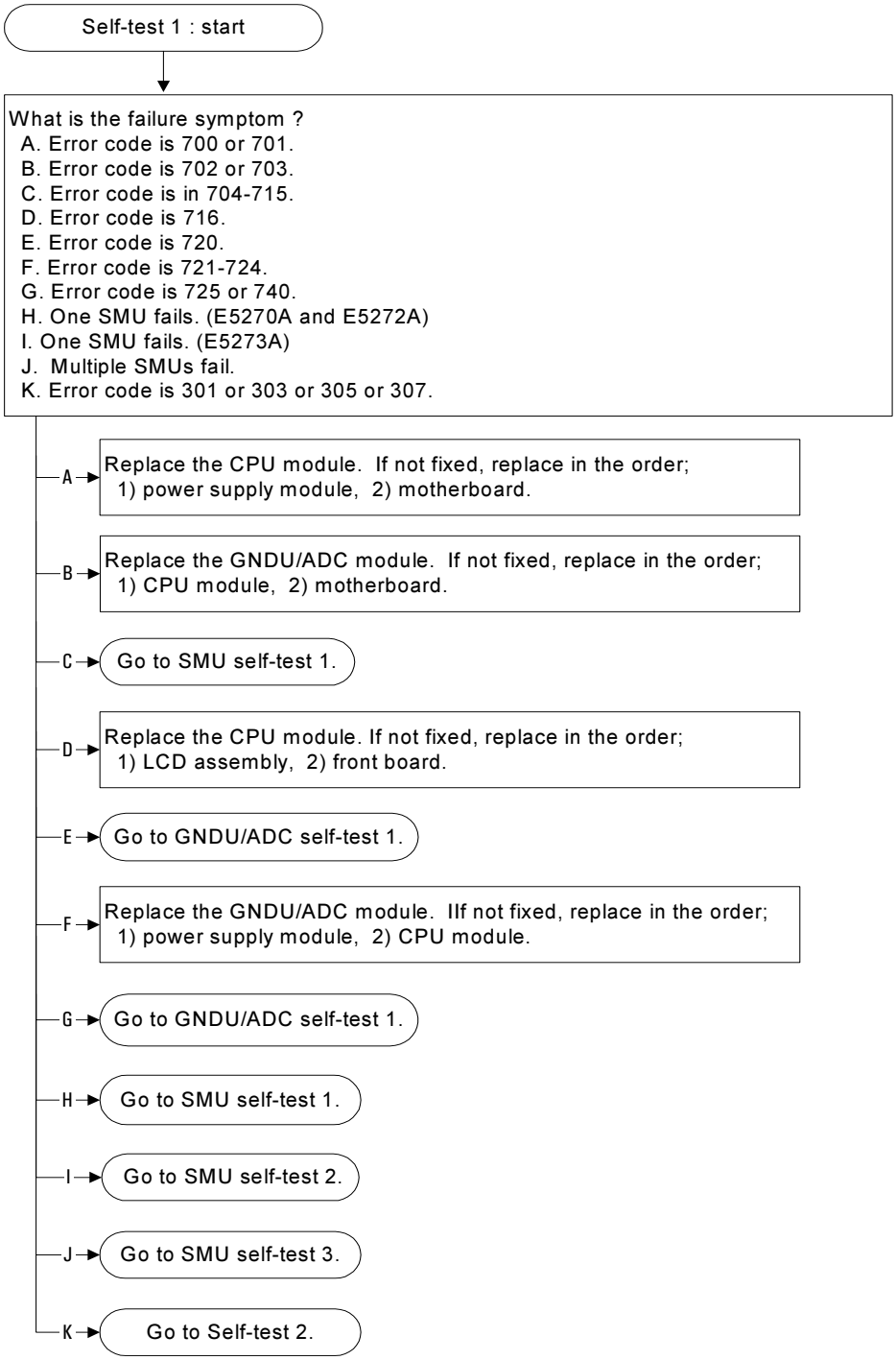
Figure 3-12 Interlock control troubleshooting flow



Self-test Failure

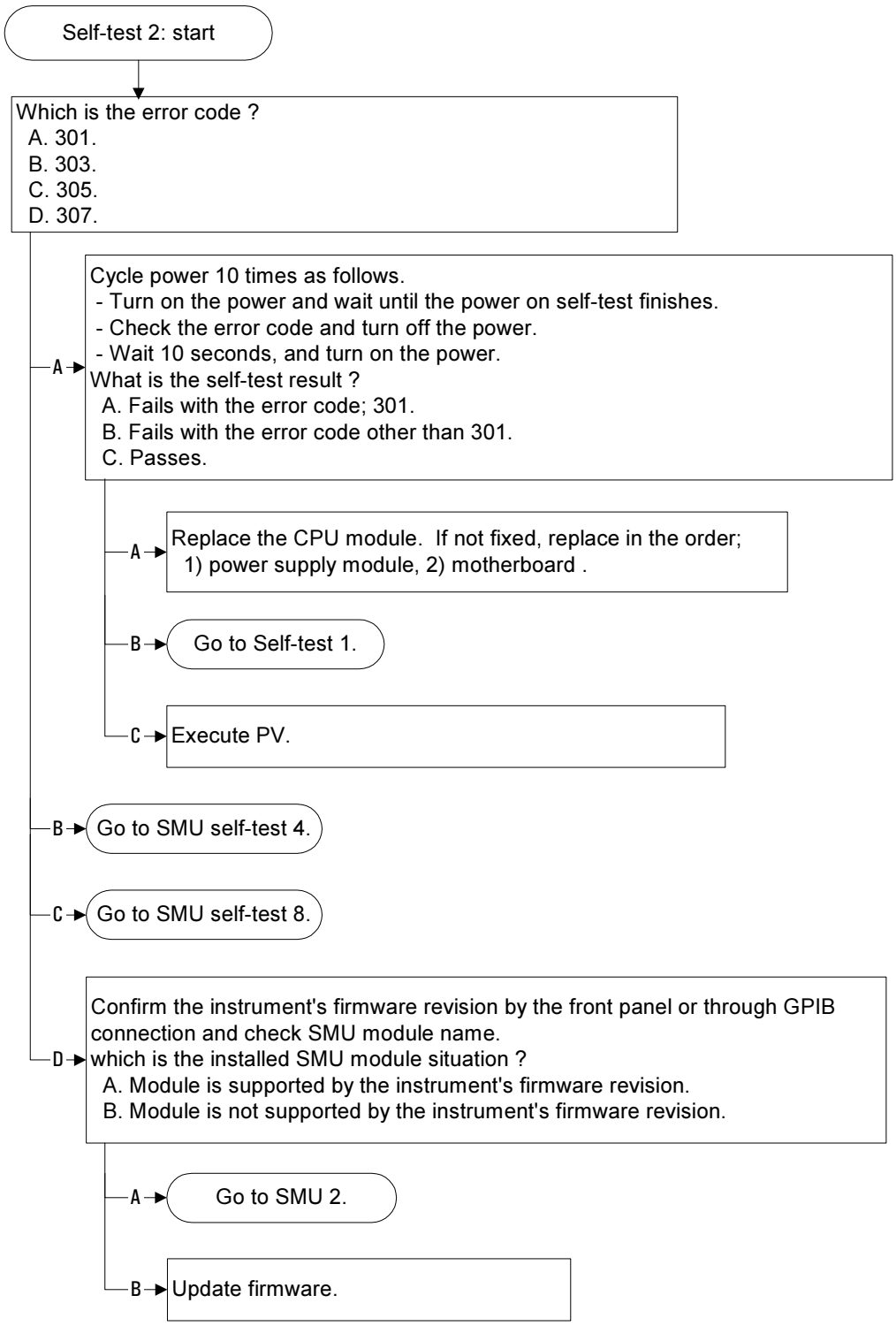
If self-test fails; troubleshooting tree top 1

Figure 3-13 Self-test troubleshooting flow: main (1 of 2)



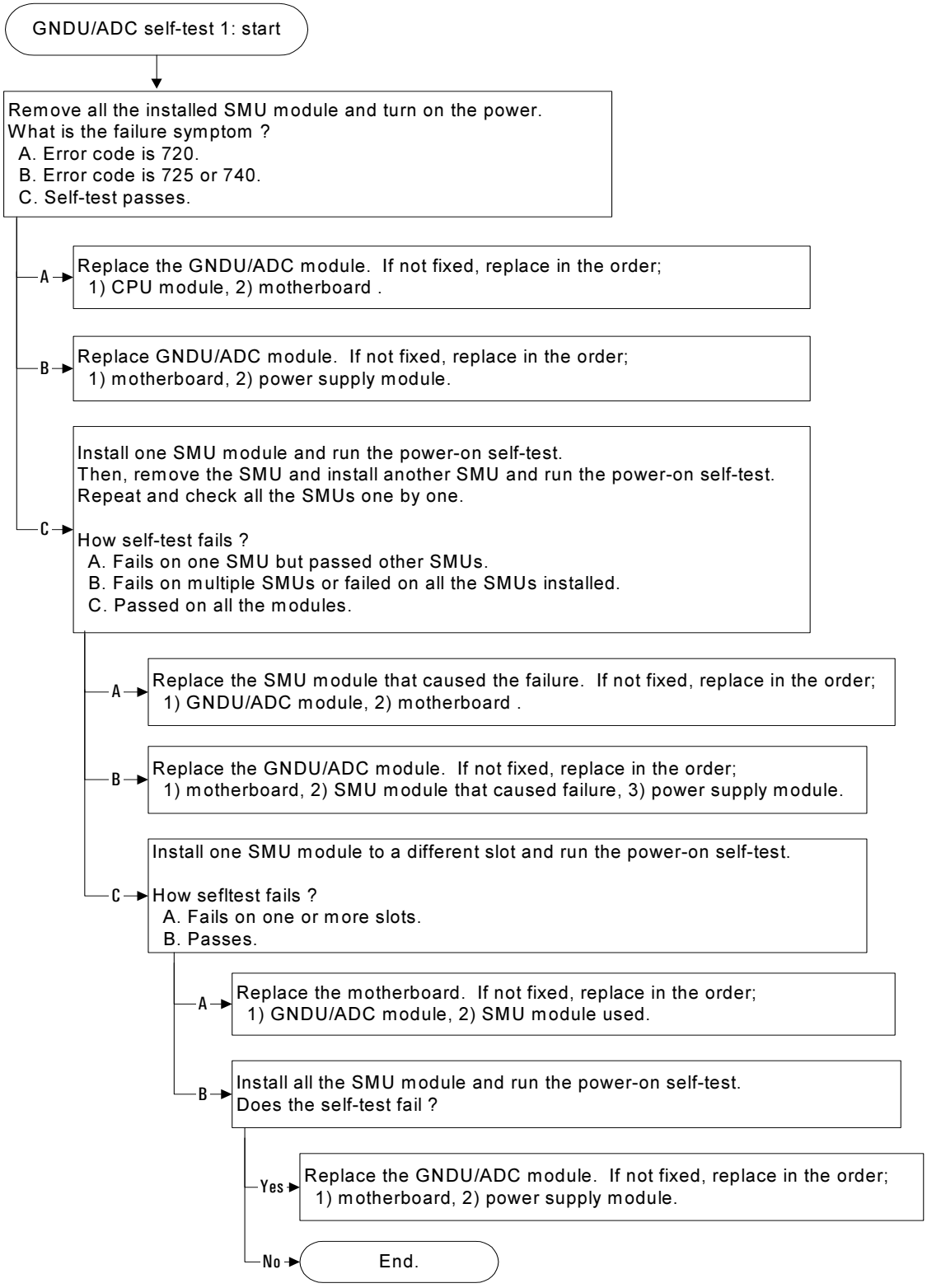
If self-test fails; troubleshooting tree top 2

Figure 3-14 Self-test troubleshooting flow: main (2 of 2)



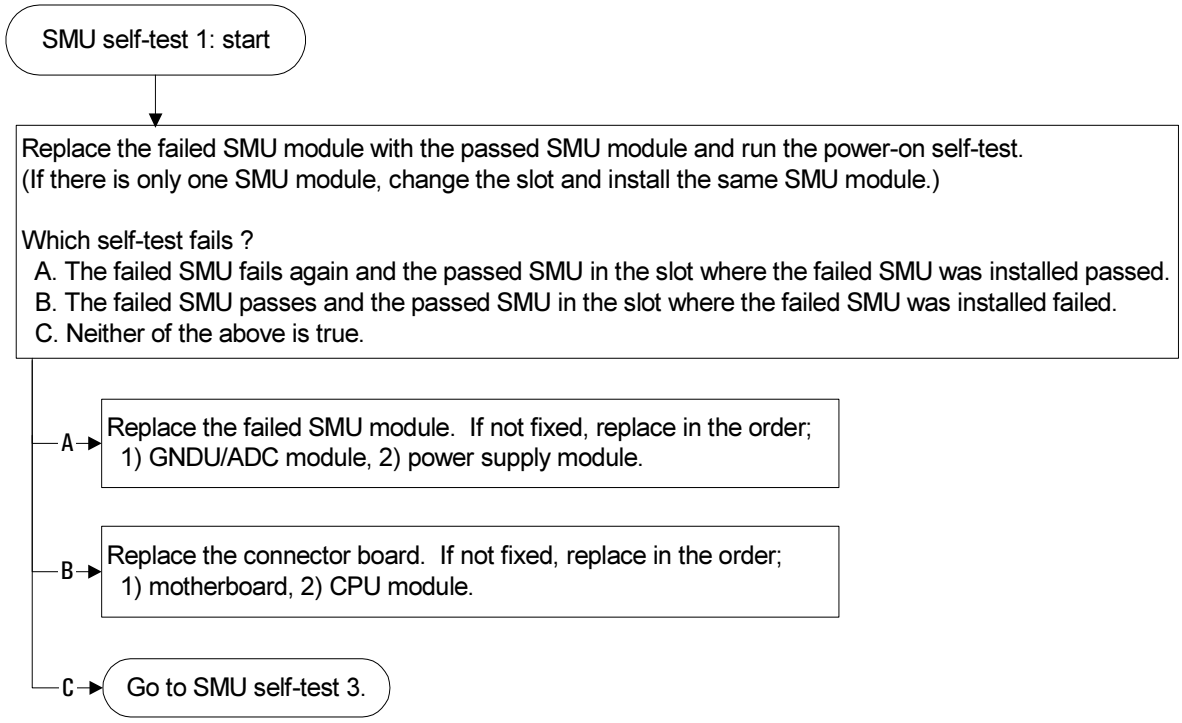
If GNDU or ADC self-test fails or ADC not installed; error code: 720, 725 or 740

Figure 3-15 GNDU/ADC self-test troubleshooting flow (1 of 1)



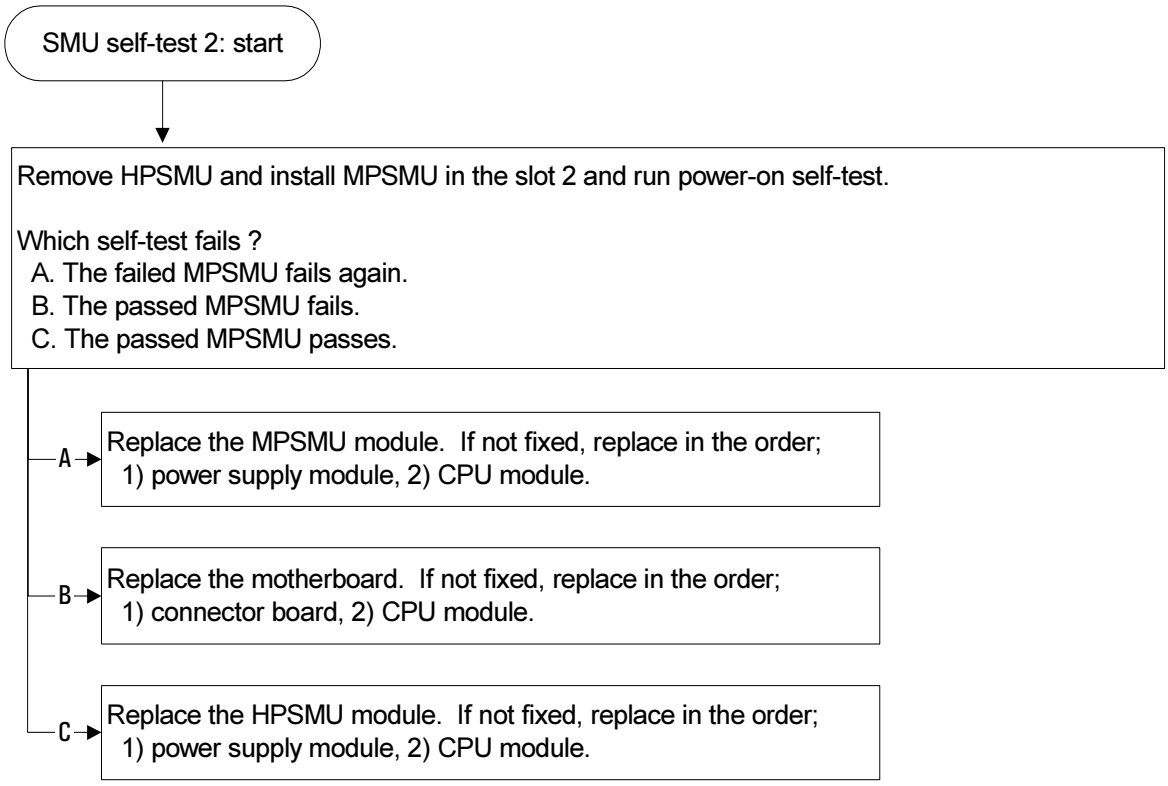
If only one SMU self-test fails (E5270A/E5272A only)

Figure 3-16 SMU self-test troubleshooting flow (1 of 8)



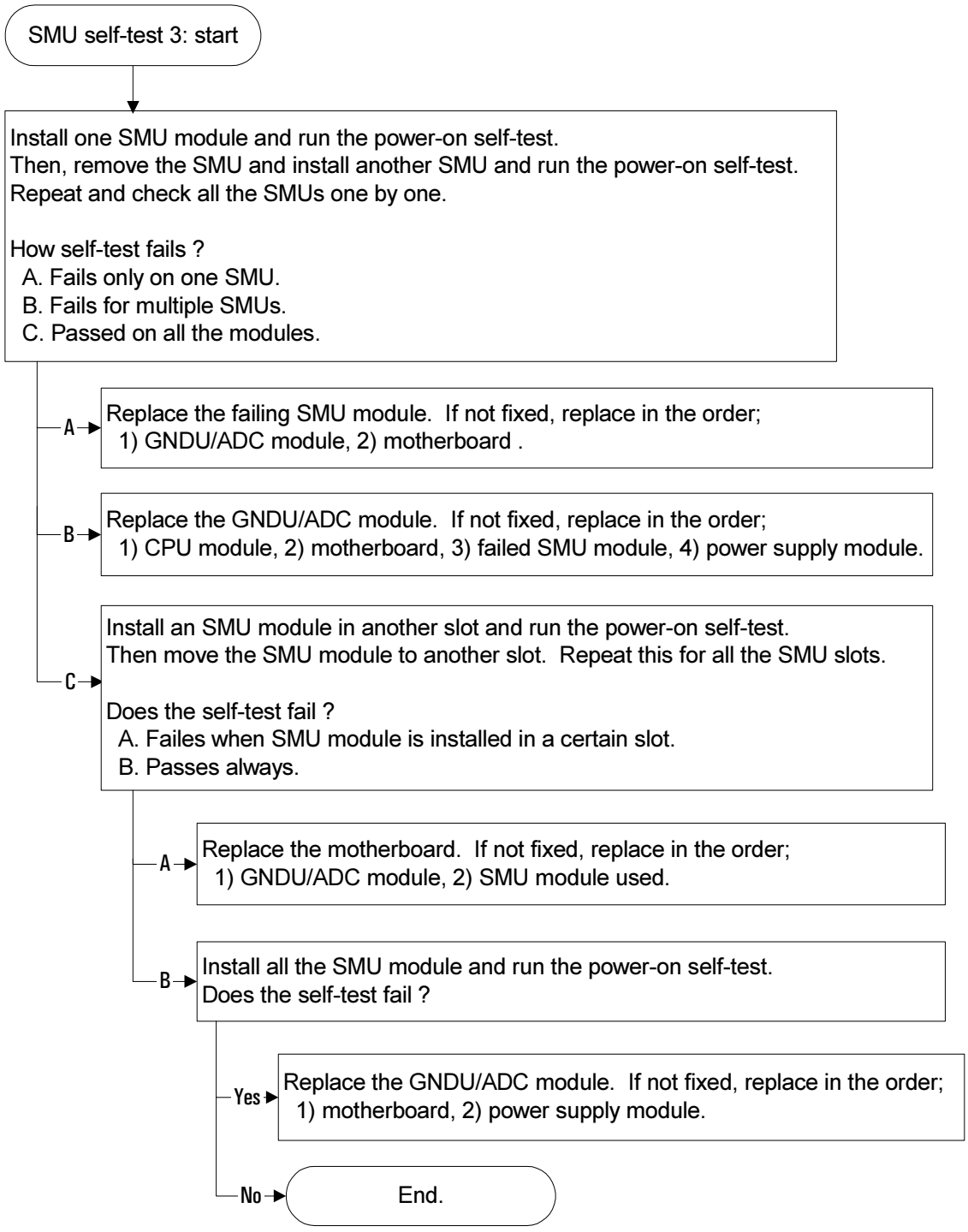
If only one SMU self-test fails (E5273A only)

Figure 3-17 SMU self-test troubleshooting flow (2 of 8)



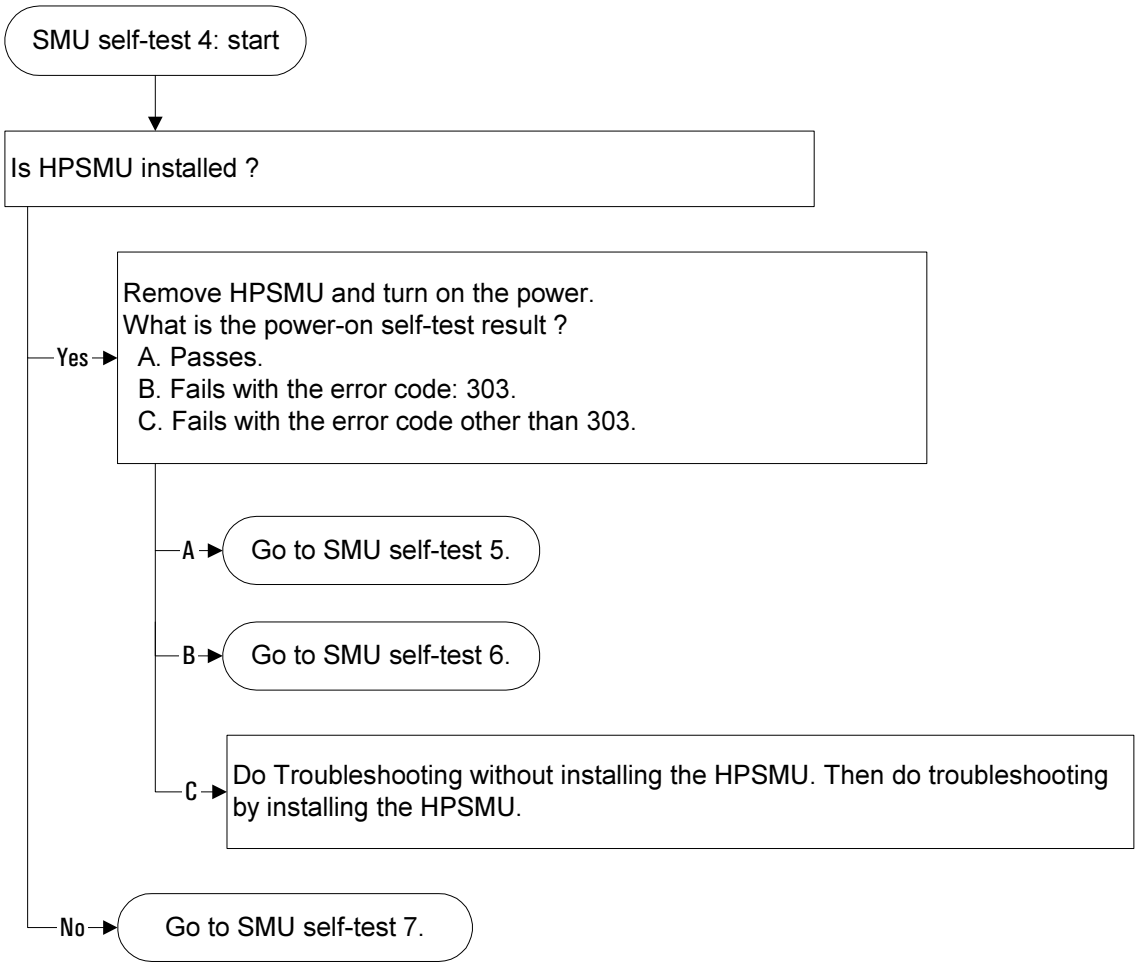
If CPU self-test fails with SMU status check fail: 704-715 or multiple self-tests fail

Figure 3-18 SMU self-test troubleshooting flow (3 of 8)



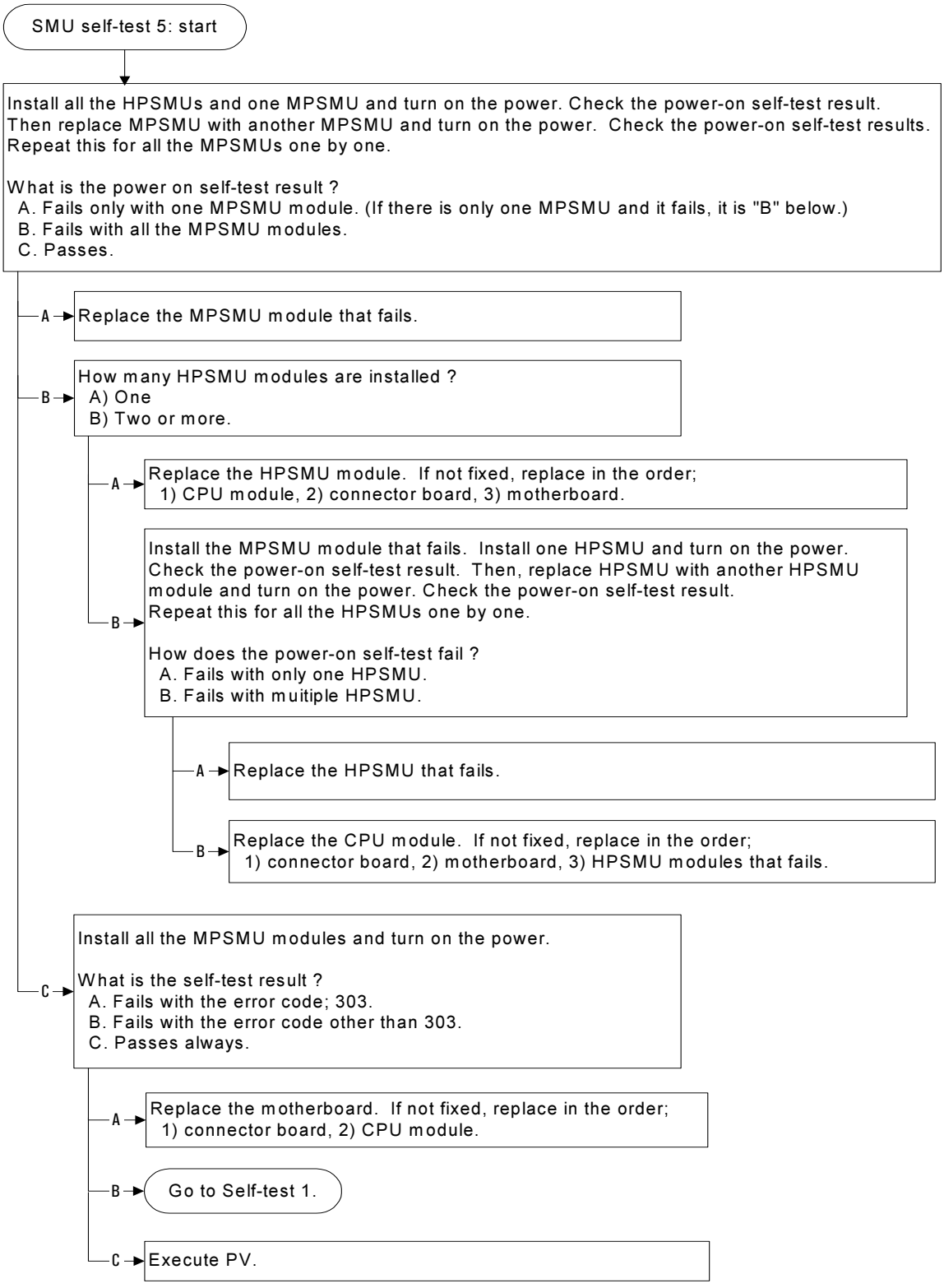
If self-test fails with an error code 303: Excess Voltage in MPSMU

Figure 3-19 SMU self-test troubleshooting flow (4 of 8)



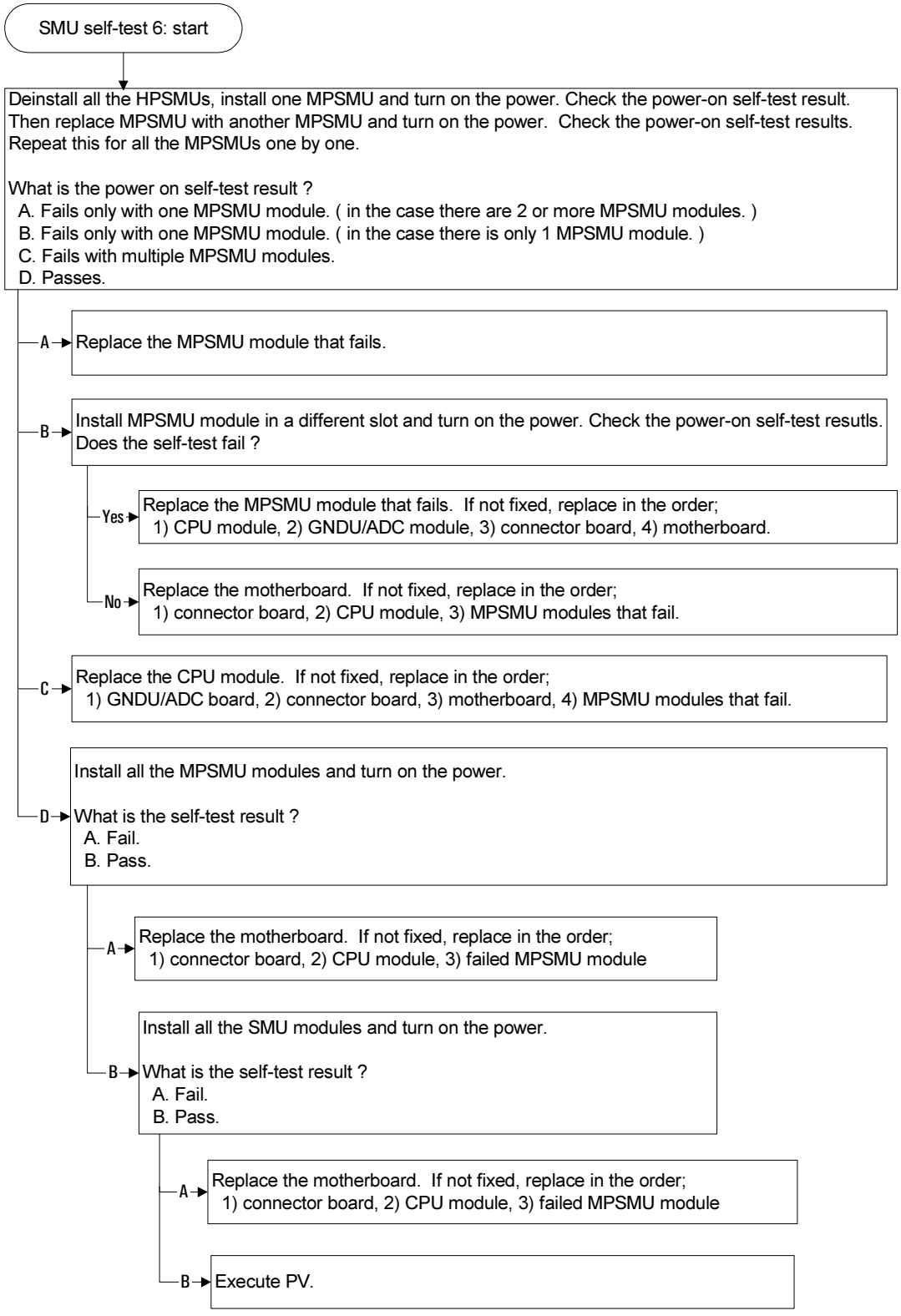
If SMU self-test fails when installing HPSMU with an error code: 303

Figure 3-20 SMU self-test troubleshooting flow (5 of 8)



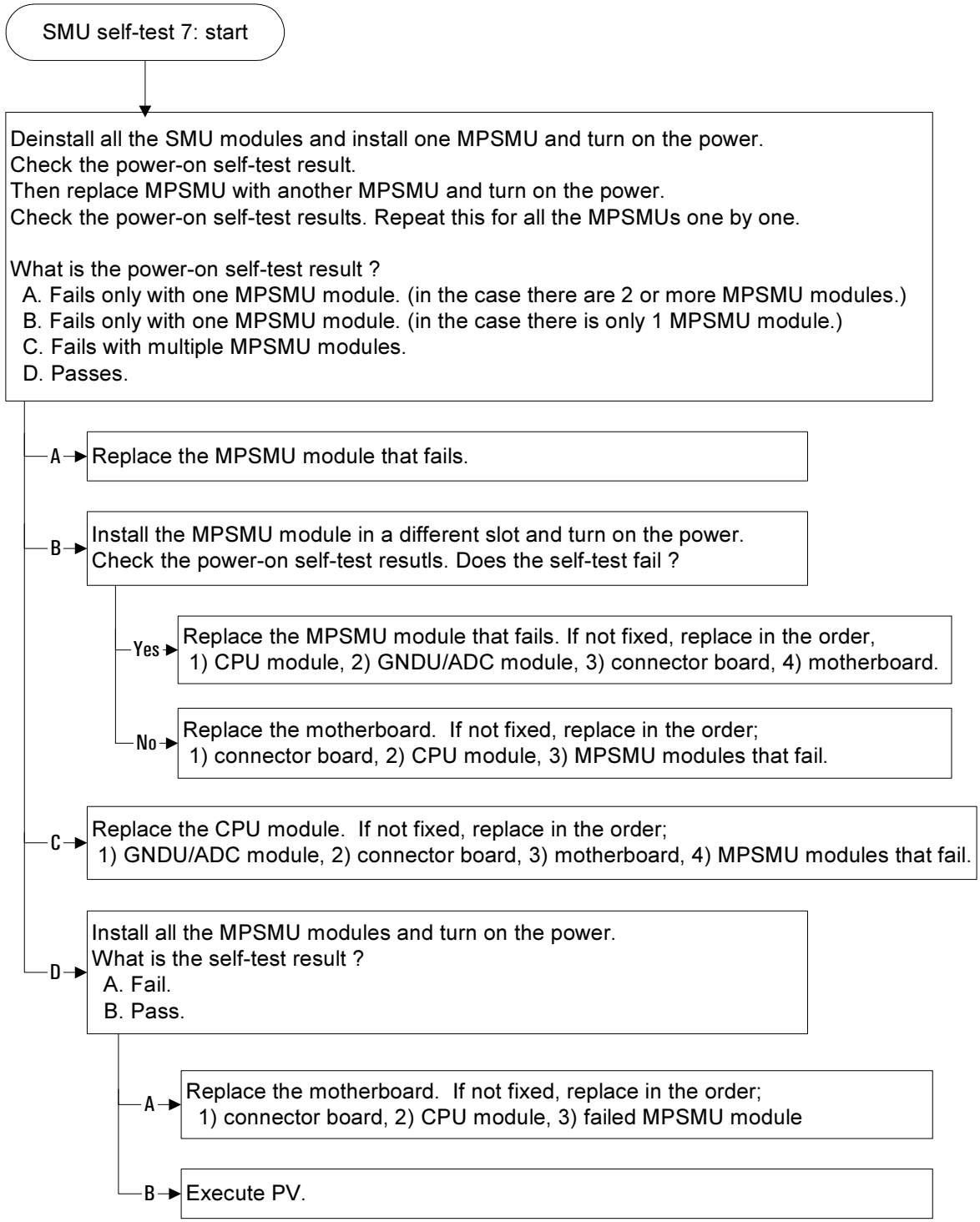
If SMU self-test fails when HPSMU is dynastically with an error code: 303

Figure 3-21 SMU self-test troubleshooting flow (6 of 8)



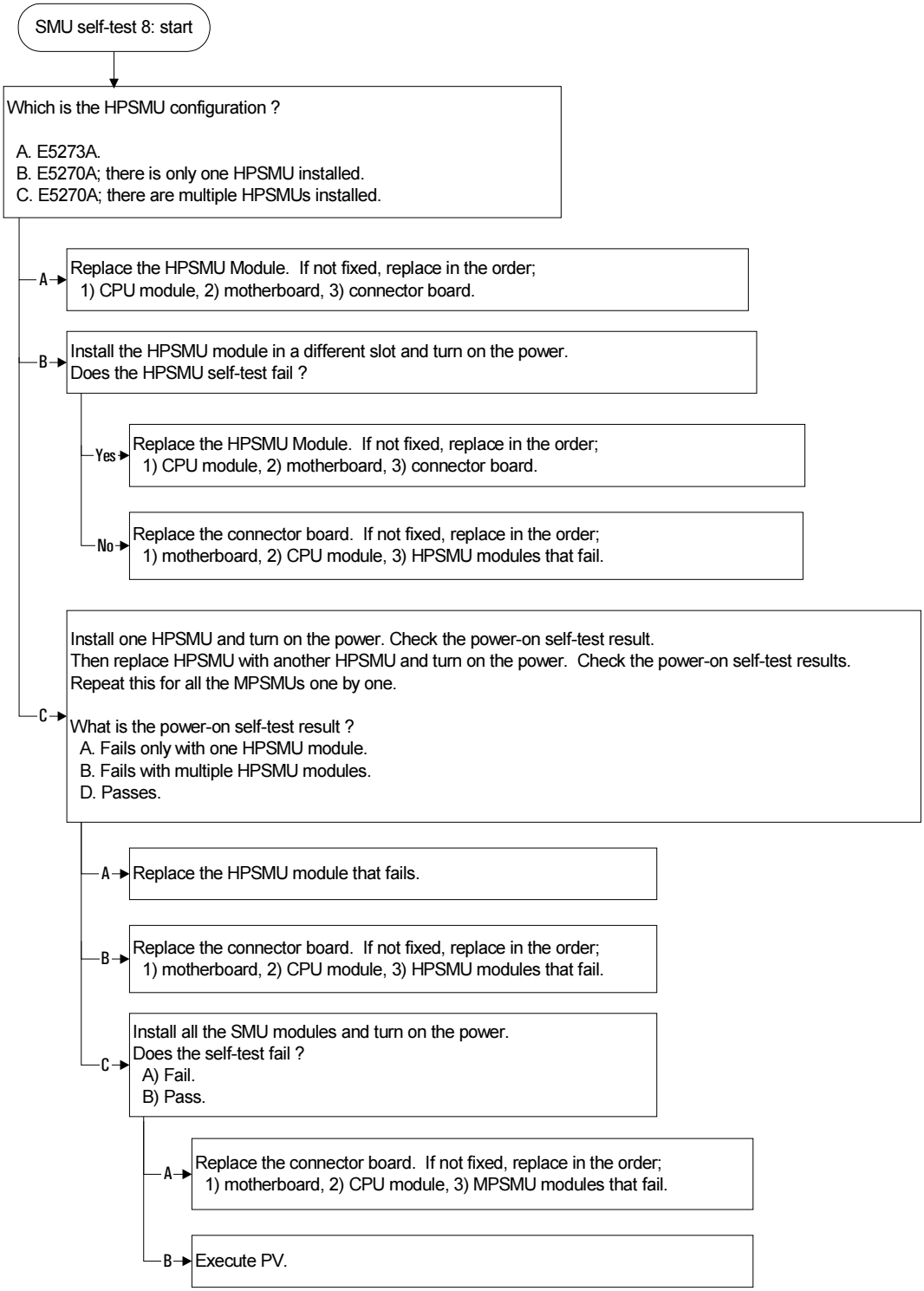
If SMU self-test fails with an error code: 303, MPSMU install error, only

Figure 3-22 SMU self-test troubleshooting flow (7 of 8)



If SMU self-test fails with an error code: 305, Excess current in HPSMU

Figure 3-23 SMU self-test troubleshooting flow (8 of 8)

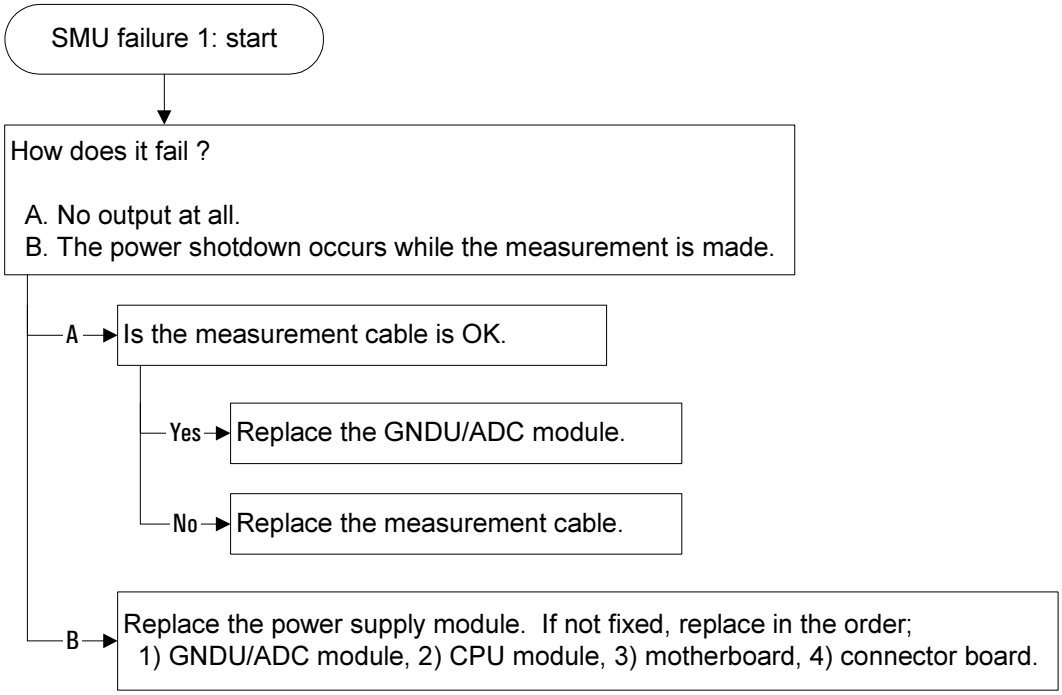


SMU and GNDU/ADC Module Failure

This section describes the troubleshooting procedure for SMU and GNDU/ADU module related failures.

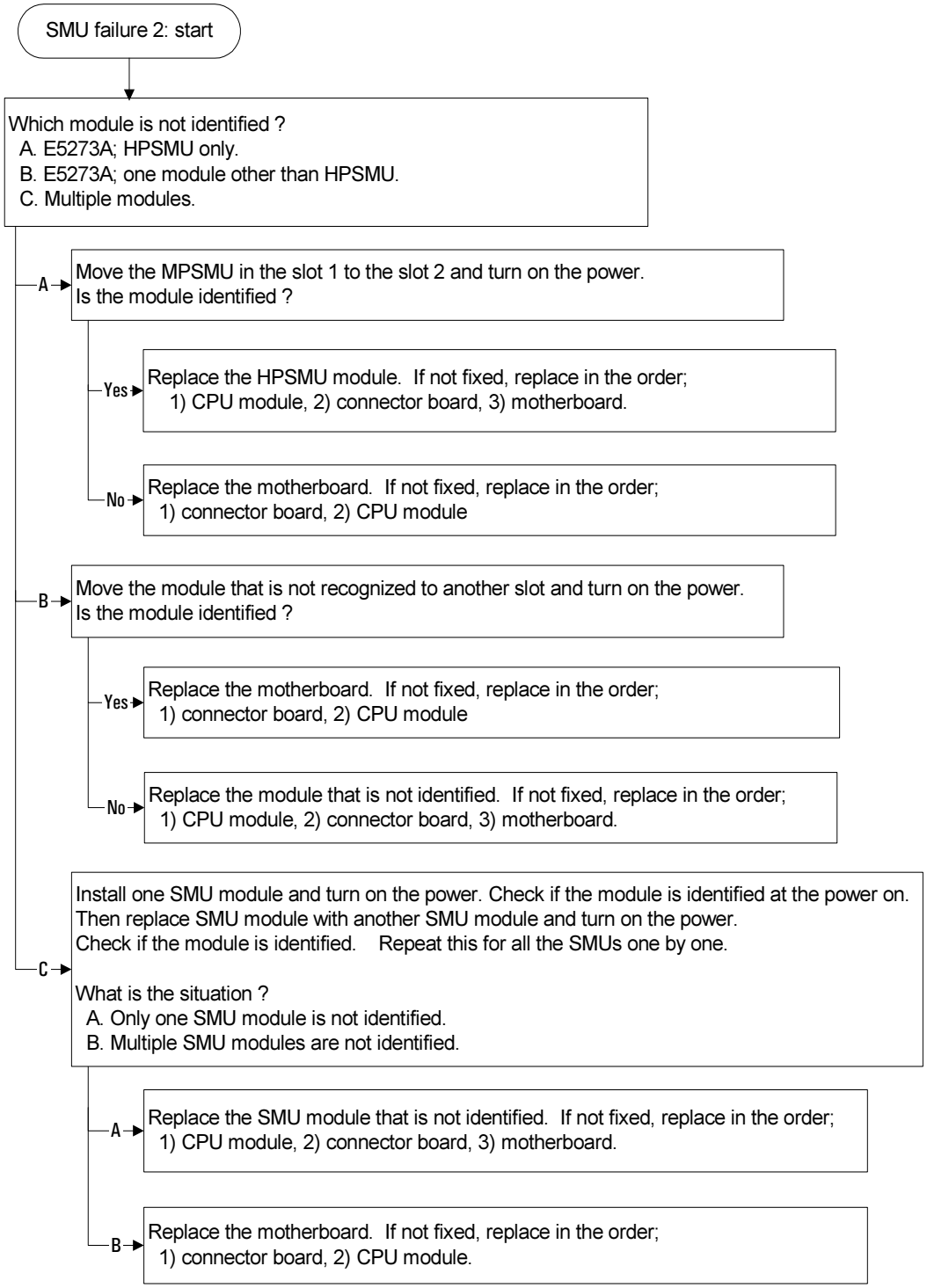
If SMU module fails (there is no output from SMU)

Figure 3-24 SMU failure troubleshooting flow (1 of 2)



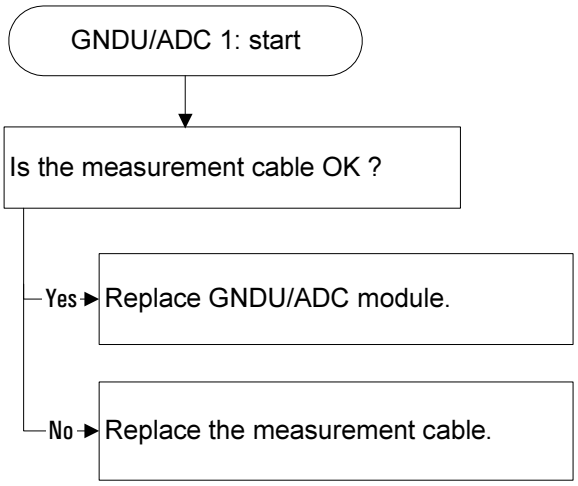
If SMU module fails (module not recognized by CPU)

Figure 3-25 SMU failure troubleshooting flow (2 of 2)



If ADC/GNDU fails but the self-test passes

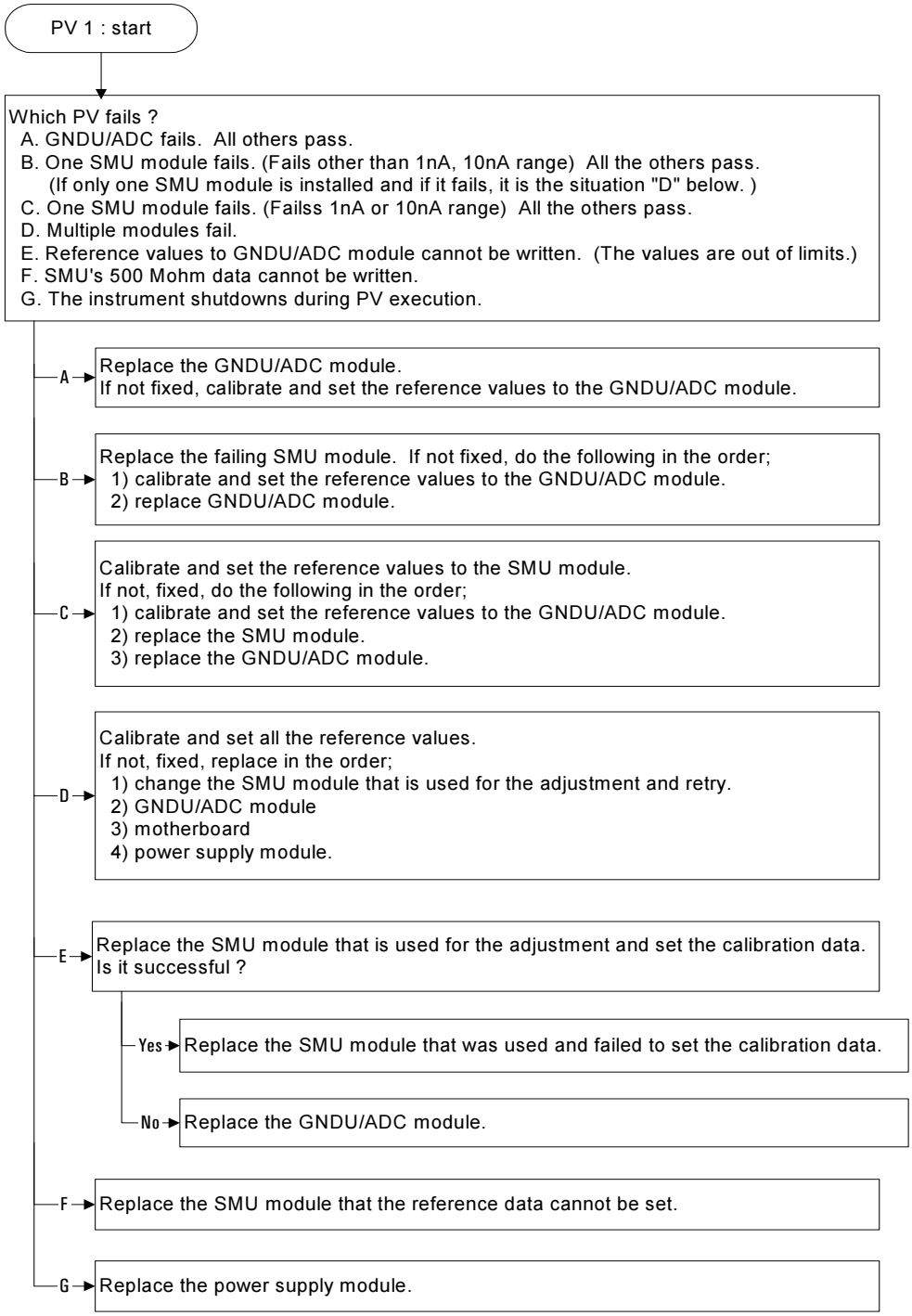
Figure 3-26 GNDU/ADC failure troubleshooting flow



PV Failure

If PV fails

Figure 3-27 PV troubleshooting flow



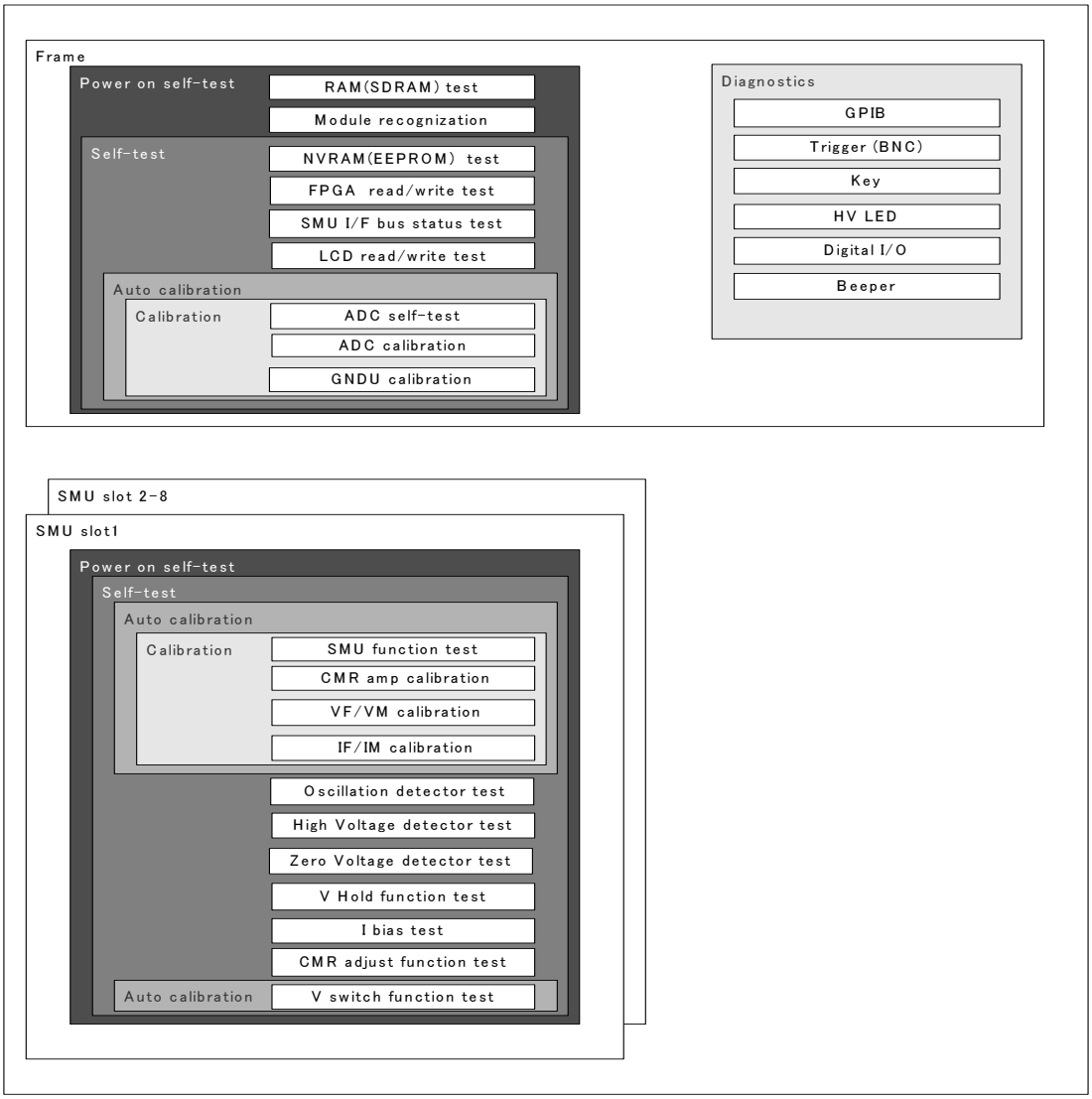
Troubleshooting Reference

This section describes the theory of the built-in self-test and diagnostics.

The Agilent E5270A/E5272A/E5273A has calibration, selftest and diagnostics functions. At turn-on, the power-on selftest is performed automatically without your assistance. The diagnostics' interactive test is performed with your assistance, such as cable connection and visual check. The selftest and the diagnostics verifies that the E5270A/E5272A/E5273A is operating but may not verify if the output and measurement are performed accurately. If you need to verify the output and measurement accuracy, use calibration and performance verification. See Chapter 2, "Calibration".

Below shows the selftest and diagnostics subtest structure.

Figure 3-28 Selftest and diagnostics structure



Self-test and power-on self-test

Executing selftest from the front panel

Execute the selftest from the front panel as follows.

1. Open the measurement terminals of the Agilent E5270A, E5272A, and E5273A.
2. Press the **Shift** key and the **Menu** key.
3. Move the cursor to SELFTEST, then press the **Enter** key.
4. Move the cursor to EXECUTE, then press the **Enter** key.
5. Press the arrow keys to select the self-test item; ALL, FRAME, or Slot n (n: 1 or 2 for 2-ch mainframe, 1 to 8 for 8-ch mainframe).
6. Press the **Enter** key to start the self-test, or press the **Exit** key to cancel it.

   During the self-test, press the **Exit** key to abort the self-test.
7. Press the **Exit** key three times to close the setup menu.

To display test results

1. Press the **Shift** key and the **Menu** key.
2. Move the cursor to SELFTEST, then press the **Enter** key.
3. Move the cursor to RESULT, then press the **Enter** key.
4. Press the arrow keys to select the self-test item; FRAME or Slot n (n: 1 or 2 for 2-ch mainframe, 1 to 8 for 8-ch mainframe). The test result is displayed for each item.
5. Press the **Exit** key three times to close the setup menu.

To use modules that failed self-test

The following procedure enables you to use a module that failed self-test or self-calibration.

1. Press the **Shift** key and the **Menu** key.
2. Move the cursor to SELFTEST, then press the **Enter** key.
3. Move the cursor to RECOVER, then press the **Enter** key.
4. Press the arrow keys to select `YES` for the message `Recover Module:`.
5. Press the **Enter** key to perform this operation, or press the **Exit** key to cancel the operation.
6. Press the **Exit** key twice to close the setup menu.

Self-test and power-on self-test reference

This section describes each self-test reference

- FRAME: RAM (SDRAM) test

  This test sets “0” and “1” to its internal circuitry and check if they are correctly set. If fails, LED on the CPU module is lit.

- FRAME: module recognition test

  This test checks the identification numbers of the installed modules and the boards.

- FRAME: NVRAM (EEPROM) test

  This test performs write and read test of the NVRAM on the CPU module.

- FRAME: FPGA write/read test

  This test performs the write and read test of the FPGA on the CPU module.

- FRAME: SMU interface bus status test

  This test checks the status signals of the SMU interface bus.

- FRAME: LCD write and read test

  This test performs the write and read test of the LCD assembly.

- FRAME: ADC self-test

  This test checks the identification number of the GNDU/ADC module and performs write and read test to the memory function of the GNDU/ADC module.

- FRAME: ADC calibration

  This test sets the calibration data to the ADC and DAC of the GNDU/ADC module and if the calibration data is out of the specified range, it gives an error.

- FRAME: GNDU calibration

  This test sets the offset calibration data. If the data is out of the specified range, it givens an error.

- SMU SLOT 1-8: SMU function test

  This test performs the function tests of the voltage force, voltage measure, I force, I measure, and the loop status.

- SMU SLOT 1-8: CMR amp calibration

  This test sets the calibration data to the common mode rejection amplifier in the SMU modules. If the calibration data is out of the specified range, this gives an error.

- SMU SLOT 1-8: VF/VM calibration

  This test sets the calibration data of the gain and the offset to the voltage force and the voltage measure function. If the calibration data is out of the specified range, it gives an error.

- SMU SLOT 1-8: IF/IM calibration

  This test sets the calibration data of the gain and the offset to the I force and I measure function. If the calibration data is out of the specified range, it gives an error.

- SMU SLOT 1-8: Oscillation detector test

  This test checks if there is no oscillation occurring at the following cases, 0V, when the voltage is changed from 0V to 94V, and when the voltage is changed from 94V to 0V. If an oscillation is found, the error OSCOUT will be set.

- SMU SLOT 1-8: High voltage detector test

  This test checks if the high voltage detector performs properly by setting the voltages to 0 V, 60 V, and - 60V. If fails, the error HV_DET_ERR will be set.

- SMU SLOT 1-8: zero voltage detector test

  This test checks if the zero voltage detector performs properly by setting the voltages to 0 V, 3 V, and -3 V. If fails, the error ZVOUT will be set.

- SMU SLOT 1-8: V hold function test

  This test checks if the V hold function performs properly by setting the voltage to 10 V, then setting V Hold to ON and change the voltage to 0V. If fails, the error V_HOLD_ERR will be set.

- SMU SLOT 1-8: I bias test

  This test checks if I Bias function, which prevents the SMU current limit values from being reversed, performs properly. If fails, the error IBIAS_ERR will be set.

- SMU SLOT 1-8: CMR adjust function test

  This test checks if CMR adjust function performs properly.

- SMU SLOT 1-8: V switch function test (HPSMU only)

  This test checks if the voltage switching function in the SMU module. If fails, VSW_FUNC_ERR will be set.

Self-calibration

Self-calibration is a part of the self-test. See Figure 3-28 and “Self-test and power-on self-test reference” on page 118 for the details.

To Perform self-calibration

1. Open the measurement terminals of the Agilent E5270A, E5272A and E5273A.
2. Press the **Shift** key and the **Menu** key.
3. Move the cursor to CAL, then press the **Enter** key.
4. Move the cursor to EXECUTE, then press the **Enter** key.
5. Press the arrow keys to select the slot to calibrate; ALL or Slot n (n: 1 or 2 for 2-ch mainframe, 1 to 8 for 8-ch mainframe).
6. Press the **Enter** key to start calibration, or press the **Exit** key to cancel calibration.

   During calibration, press the **Exit** key to abort it.
7. Press the **Exit** key three times to close the setup menu.

To display calibration results

1. Press the **Shift** key and the **Menu** key.
2. Move the cursor to CAL, then press the **Enter** key.
3. Move the cursor to RESULT, then press the **Enter** key.
4. Press the arrow keys to select the calibration item; FRAME or Slot n (n: 1 or 2 for 2-ch mainframe, 1 to 8 for 8-ch mainframe). The calibration result is displayed for each calibration item.
5. Press the **Exit** key three times to close the setup menu.

Diagnostics

To perform diagnostics

1. Press the **Shift** key and the **Menu** key.
2. Move the cursor to DIAG, then press the **Enter** key.
3. Move the cursor to EXECUTE, then press the **Enter** key.
4. Press the arrow keys to select the diagnostics item; GPIB, TRIGGER (BNC), KEY, HV-LED, DGTL-I/O, or BEEPER.

   Before starting the diagnostics, perform the following:

   - For GPIB, disconnect the GPIB cable.
   - For TRIGGER (BNC), connect a BNC cable between the Ext Trig In and Out connectors.
   - For DGTL-I/O, disconnect any cable from the digital I/O port.
   - For other diagnostics, no action is required.
5. Press the **Enter** key to start diagnostics, or press the **Exit** key to cancel diagnostics.

   After starting the diagnostics, perform the following, or press the **Exit** key to abort the diagnostics.

   - For KEY, press any front panel key; then the LCD displays the key name. Repeat this for all front panel keys.

     If all responses were good, press the **Enter** key twice to stop.

     If any response was bad, press the **Exit** key twice to stop.
   - For HV-LED, confirm that the LED blinks.

     If the LED is blinking, press the **Enter** key to stop.

     If the LED does not blink, press the **Exit** key to stop.
   - For BEEPER, confirm that the beeper makes two sounds every second.

     If you hear it, press the **Enter** key to stop.

     If you do not hear it, press the **Exit** key to stop.
   - For other diagnostics, no action is required.
6. Press the **Exit** key three times to close the setup menu.

To display diagnostics results

1. Press the **Shift** key and the **Menu** key.
2. Move the cursor to DIAG, then press the **Enter** key.
3. Move the cursor to RESULT, then press the **Enter** key.
4. Press the arrow keys to select the diagnostics item; GPIB, TRIGGER (BNC), KEY, HV-LED, DGTL-I/O, or BEEPER. The diagnostics result is displayed for each diagnostics item.
5. Press the **Exit** key three times to close the setup menu.

Diagnostics reference

This section explains diagnostics' subtests.

- GPIB test

  This test sets the SRQ status and read back to check if the SRQ status is read correctly.

- Trigger (BNC) test

  This test sends the BNC trigger signal from Ext Trig Out terminal and checks if the trigger is correctly received from the Ext Trig In terminal.

- Key test

  This test displays the name of the key that is pushed in the LCD panel and you can check if it works with your eyes.

- HV LED test

  This test makes the HV LED lit and you can check if it works with your eyes.

- Digital I/O test

  This test sets the each pin to "1" and "0" status and checks if they are set correctly.

- Beeper test

  This test makes the beeper beep and you can check if it works with your ears.

To Read Error Message

1. Press the **Menu** key.
2. Move the cursor to ERROR, then press the **Enter** key.
3. Move the cursor to DISPLAY, then press the **Enter** key to display the message.
4. Press the arrow keys to read another error message. A maximum of four error messages can be stored.
5. Press the **Exit** key three times to close the setup menu.

To clear error buffer

1. Press the **Menu** key.
2. Move the cursor to ERROR, then press the **Enter** key.
3. Move the cursor to CLEAR, then press the **Enter** key.
4. Press the arrow key to select `YES` for the message `Clear Error Buffer:`.
5. Press the **Enter** key to clear the error buffer, or press the **Exit** key to cancel operation.
6. Press the **Exit** key twice to close the setup menu.

To Display Firmware Revision

1. Press the **Menu** key.
2. Move the cursor to CONFIG, then press the **Enter** key.
3. Move the cursor to REVISION, then press the **Enter** key. The firmware revision is displayed.
4. Press the **Exit** key three times to close the setup menu.

4 Replacement Procedure

This chapter describes the assemblies replacement procedures. Each section explains how to remove the assemblies from Agilent E5270A, E5272A, or E5273A.

WARNING **Only personnel with knowledge of electric circuitry and an awareness of the hazards involved should remove and install printed circuit board assemblies.**

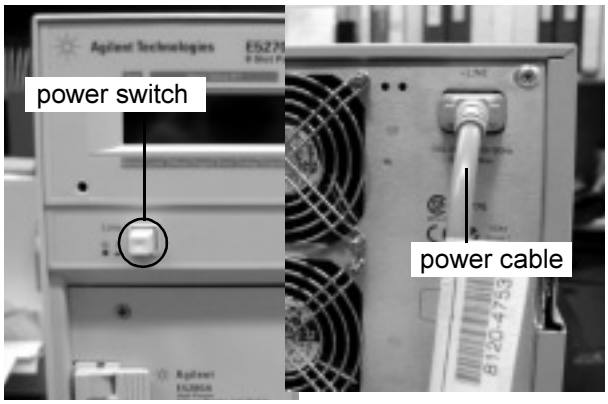
CAUTION

- To avoid electrostatic damage (ESD), use an anti-static mat and wrist strap.
- After removing a module, hold the module so that the printed circuit board of the module does not bend. Bending the board can damage the printed patterns.
- Oil, perspiration, fibrous dust, and dirt degrade the insulation of the circuit, thus lowering measurement accuracy. Wear rubber gloves when handling the print circuit boards.

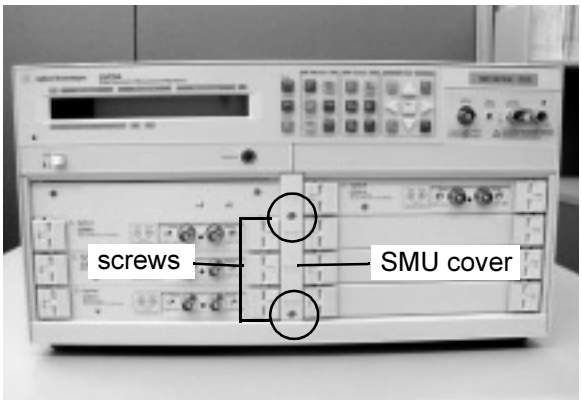
The chapter contains the following sections:

Removing SMU Module

This section describes how to remove the SMU module.



1. Turn off power, then disconnect the power cable.

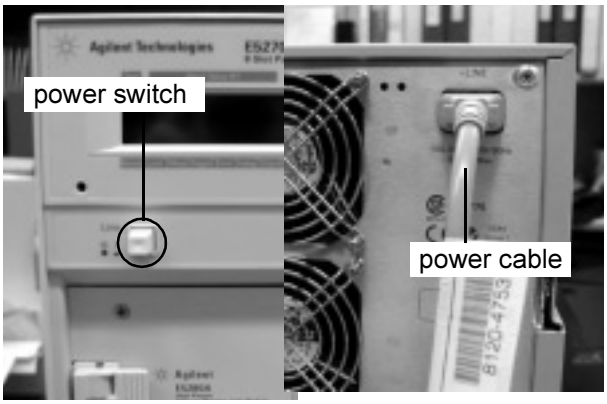


2. Loosen the screws on the SMU cover.
3. Remove the SMU cover.

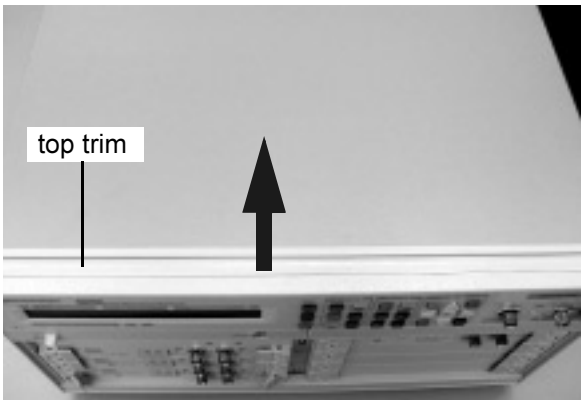
4. Holding module extractor, and gently pull the SMU module.

Removing GNDU/ADC Module

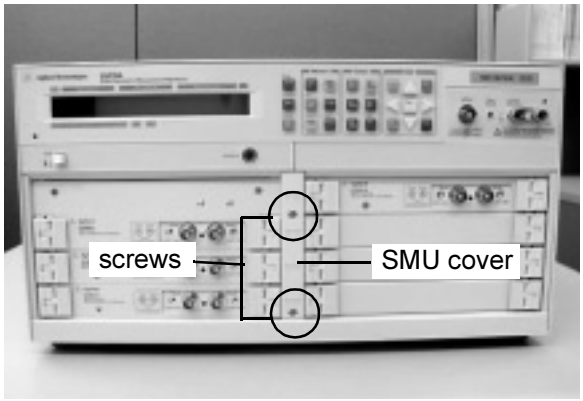
This section describes how to remove GNDU/ADC module.



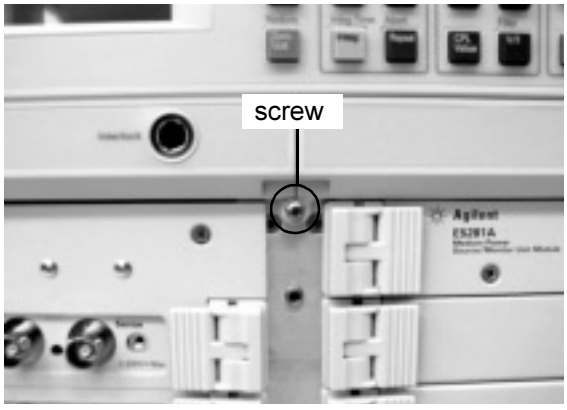
1. Turn off power, then disconnect the power cable.



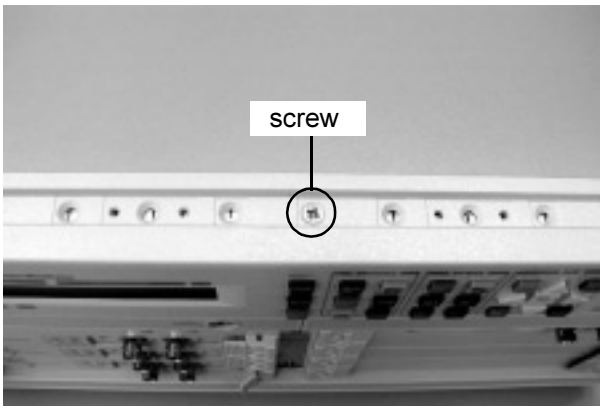
2. Remove the top trim.



3. Loosen the screws on the SMU cover.
4. Remove the SMU cover.



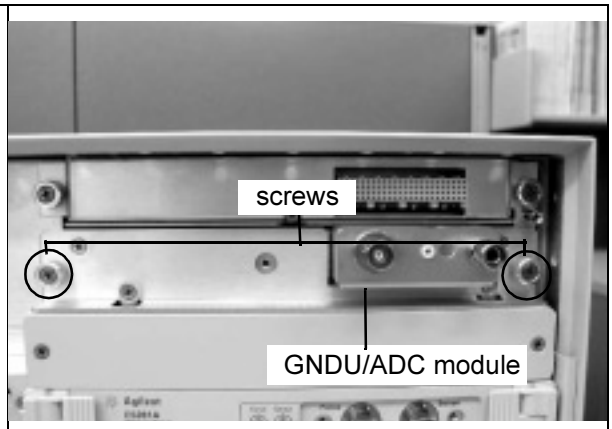
5. Loosen the screw on the front of the mainframe.



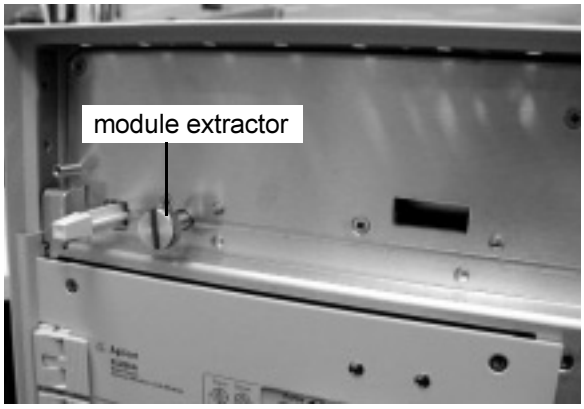
6. Loosen the screw at the top of mainframe.

7. Remove the shorting bar from the circuit common.

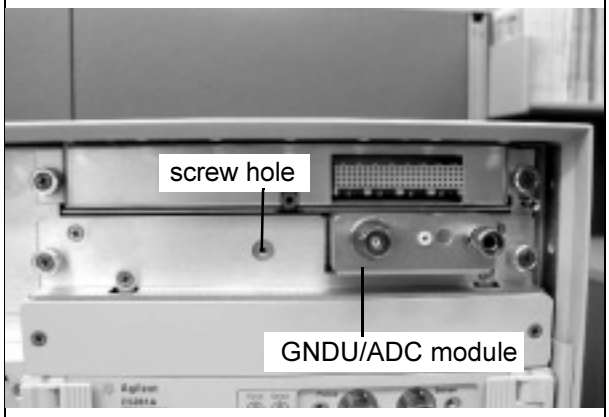
8. With the H3 hex wrench, gently loosen the screws on the front panel. The front panel assembly is moved forward by the screws.



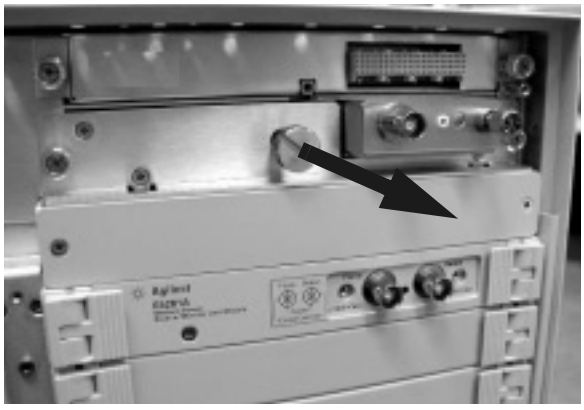
9. Loosen the screws on GNDU/ADC module.



10. Remove the module extractor.



11. Screw the module extractor into the screw hole on the GNDU/ADC module.

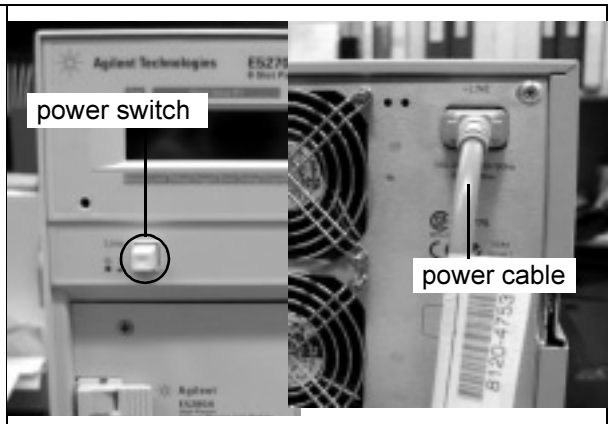


12. Pull the screwed-in module extractor.

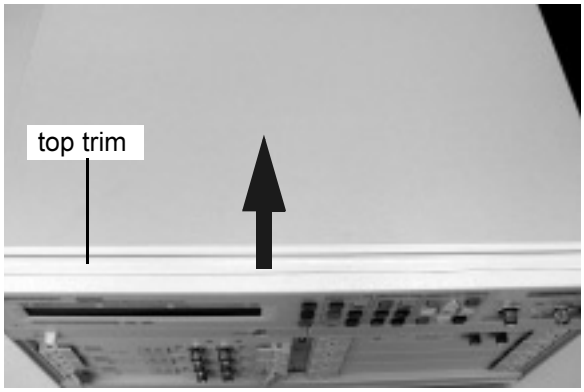
Removing CPU Module

This section describes how to remove CPU module.

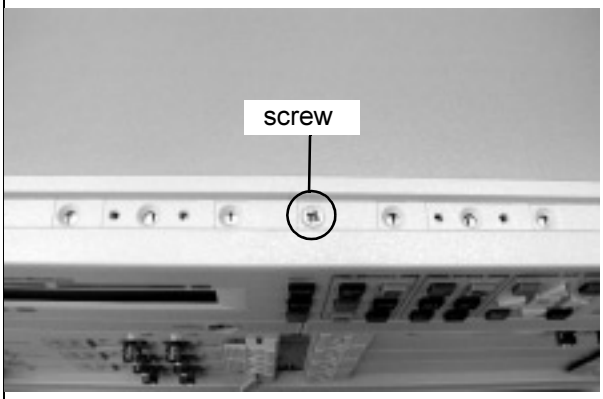
1. Turn on power.
2. Confirm and jot down the present frequency setting using the following procedure.
   a. Press **[Menu]**.
   b. Select **CONFIG**, and press **[Enter]**.
   c. Select **LINEFREQ**, and press **[Enter]**.
   The present frequency setting is displayed.
3. Confirm and jot down the present firmware revision using the following procedure.
   a. Select **VERSION**, and press **[Enter]**. The present firmware revision is displayed.



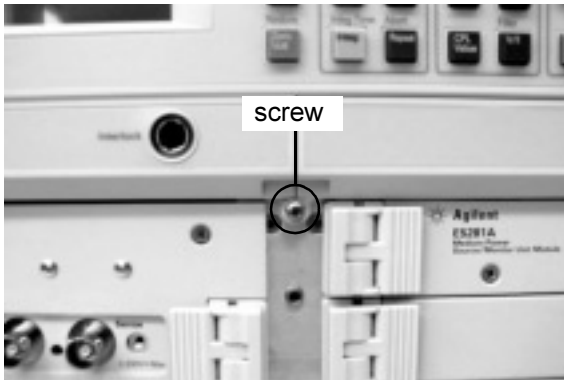
4. Turn off power, then disconnect the power cable.



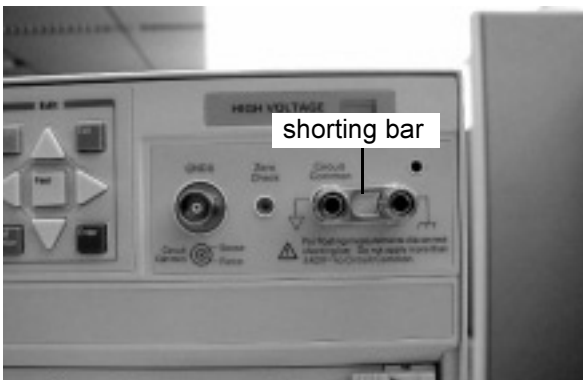
5. Remove the top trim.



6. Loosen the screw at the top of mainframe.

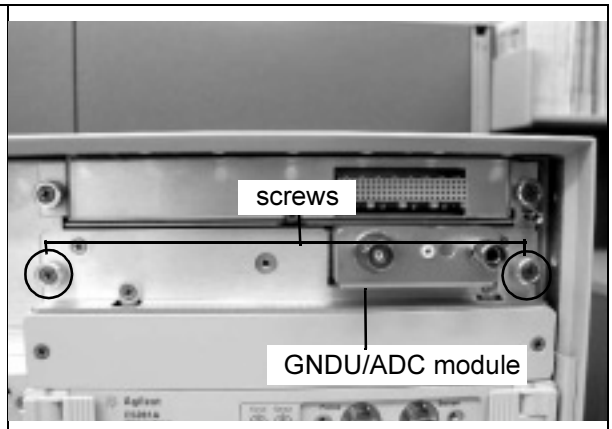


7. Loosen the screw on the front of the mainframe.

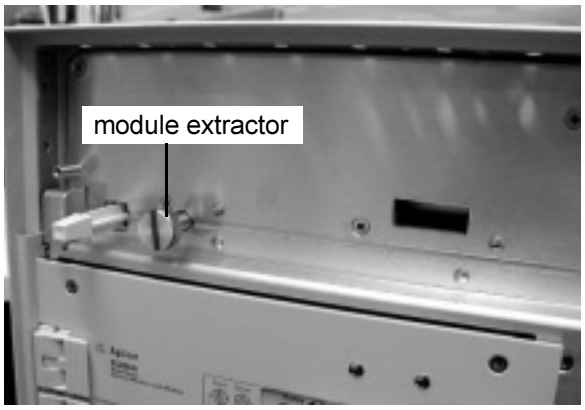


8. Remove the shorting bar from the circuit common.

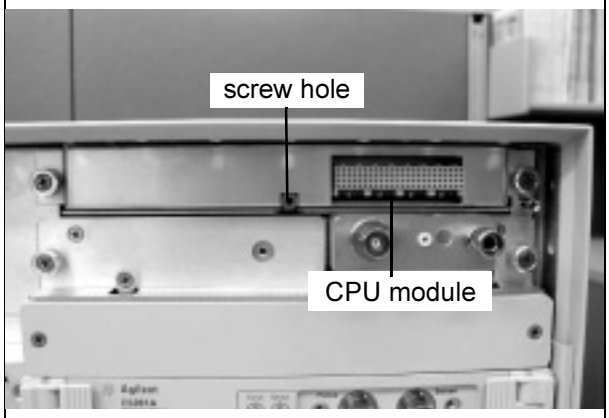
9. With the H3 hex wrench, gently loosen the screws on the front panel.



10. Loosen the screws on CPU module.



11. Remove the module extractor.



12. Screw the module extractor into the screw hole on the CPU module.

13. Pull the screwed-in module extractor.

14. Turn on power.

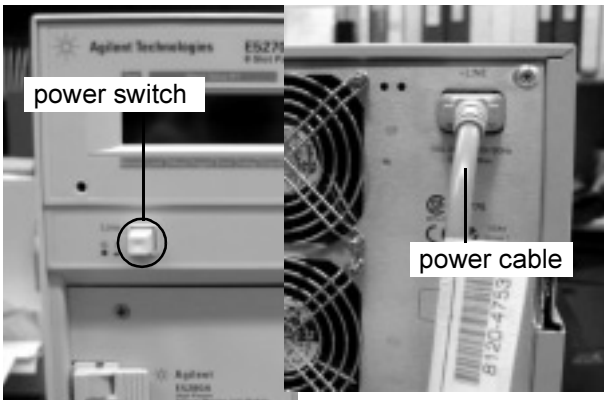
15. Set the power line frequency using the following procedure.

    a. Press **[Menu]**.
    b. Select **CONFIG**, and press **[Enter]**.
    c. Select **LINEFREQ**, and press **[Enter]**.
    d. Select original frequency by using arrow key.

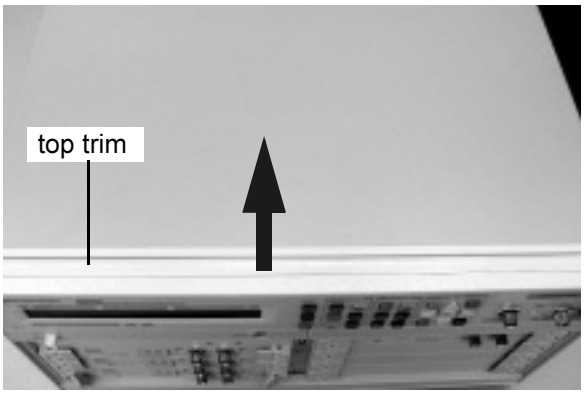
16. Confirm the firmware revisions. If the revisions are older than the original revisions, update the firmware. (See “Updating Firmware”.)

Removing Keyboard and LCD Assemblies

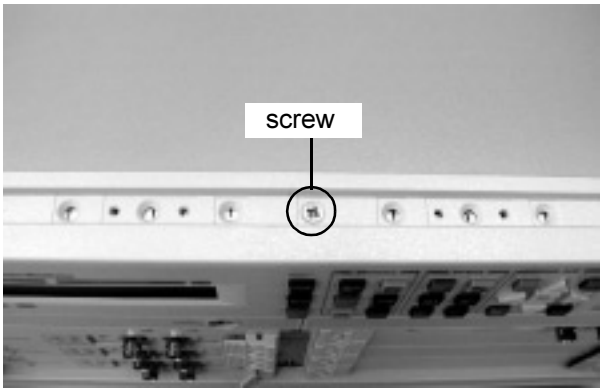
This section describes how to remove keyboard and LCD assemblies.



1. Turn off power, then disconnect the power cable.



2. Remove the top trim.

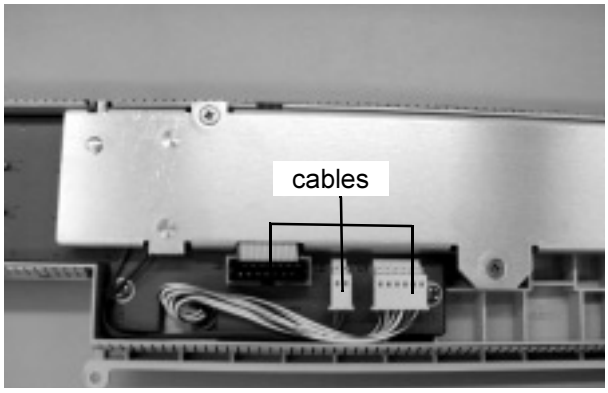


3. Loosen the screw at the top of mainframe.

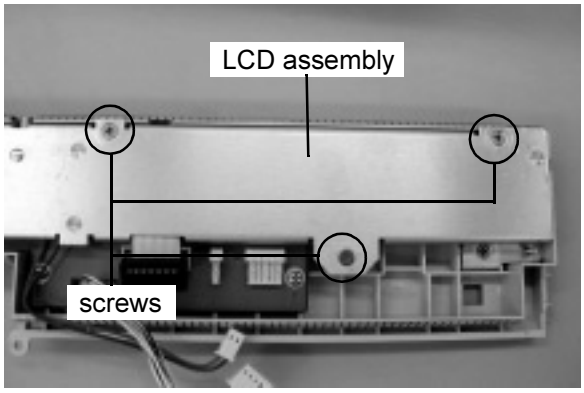
4. Loosen the screw on the front of the mainframe.

5. Remove the shorting bar from the circuit common.

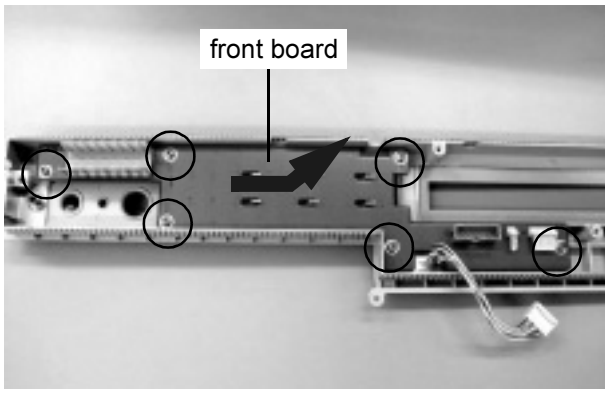
6. With the H3 hex wrench, gently loosen the screws on the front panel.



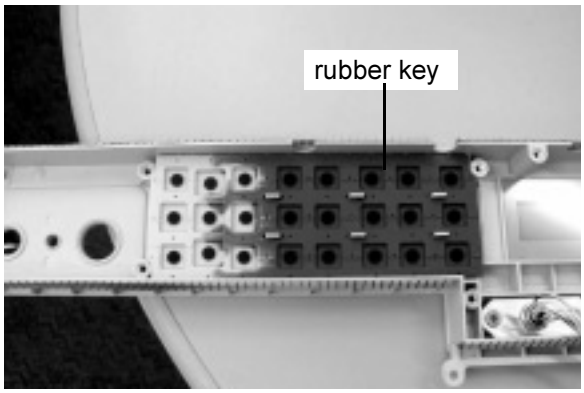
7. Disconnect the LCD and interlock cables.



8. Loosen the screws on the LCD assembly.
9. Remove the LCD assembly from the front panel.



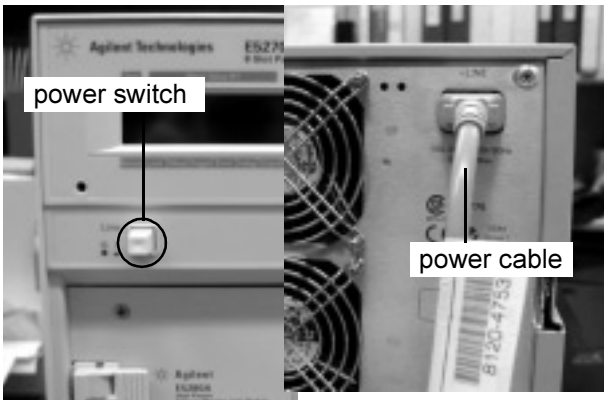
10. Loosen the screws on the front board.
11. Slide and remove the front board.



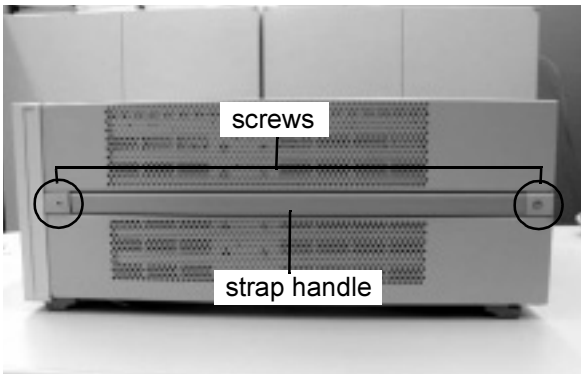
12. Remove the rubber key.

Removing Power Supply Module

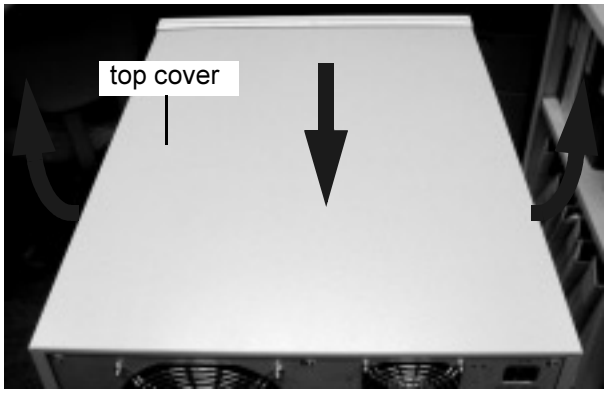
This section describes how to remove power supply module.



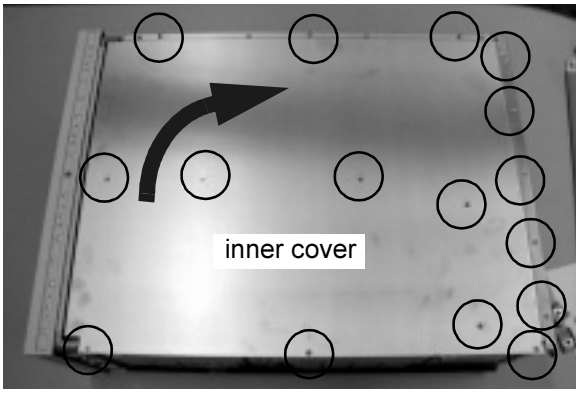
1. Turn off power, then disconnect the power cable.



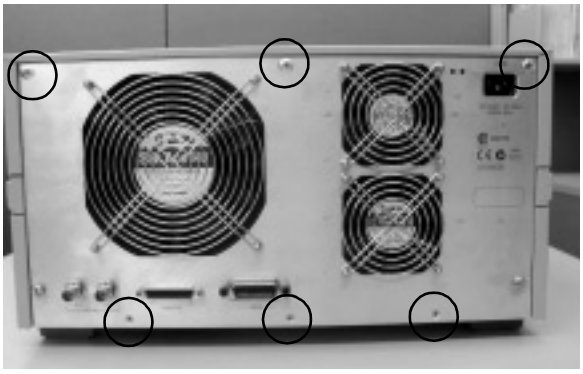
2. Loosen the screws of the strap handles.
3. Remove the strap handles.



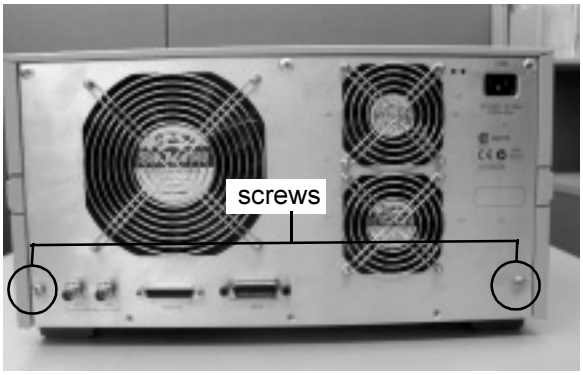
4. To remove the top cover, slide the cover to backward, splay the side of the cover, and then lift up the cover.



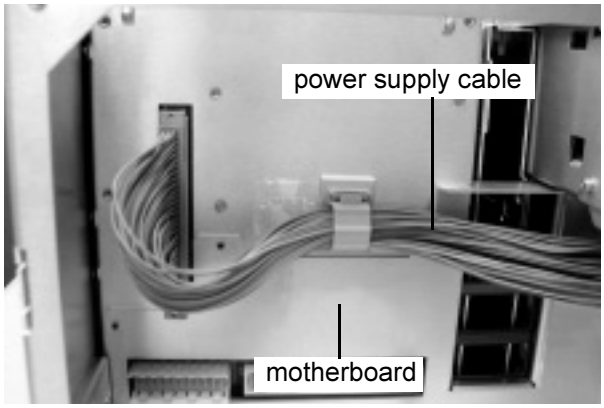
5. Loosen the screws on the inner cover.
6. Remove the inner cover.



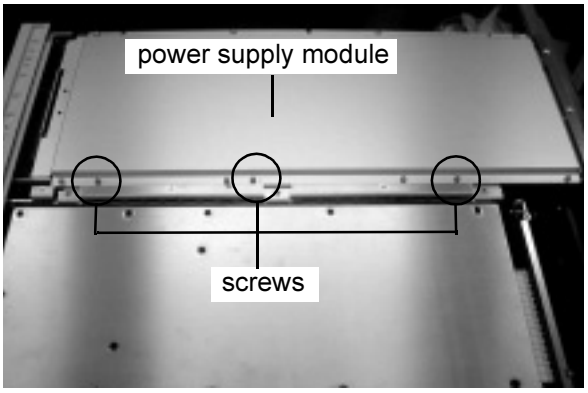
7. (For E5270A only) Loosen the six screws on the rear panel.



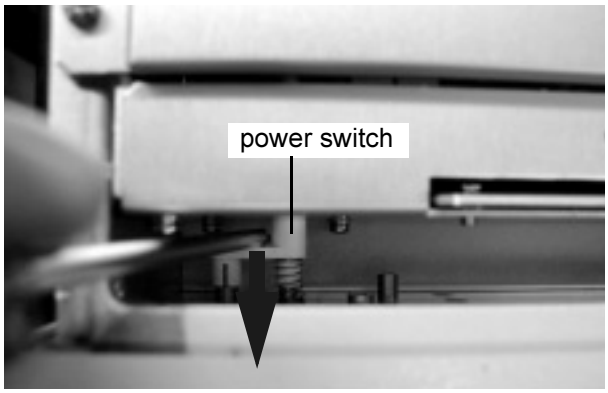
8. (For E5270A only) Gently loosen the two screws on the rear panel. The rear panel is moved forward by the screws.



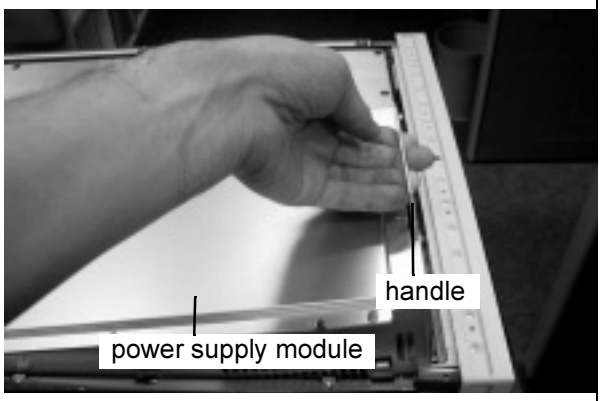
9. Disconnect the power supply cable from the motherboard.



10. Loosen the screws marked with arrow.



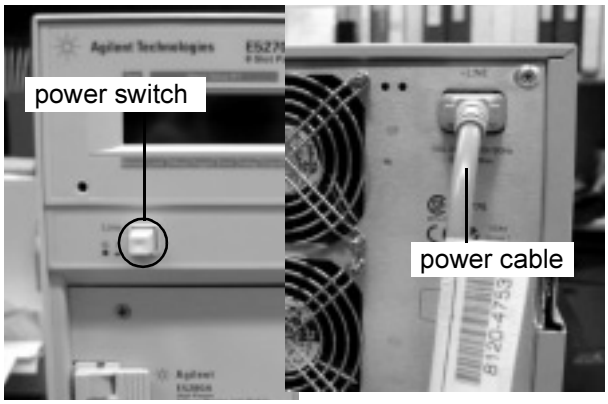
11. Move the power switch to forward with a screwdriver. The power switch will be fixed.



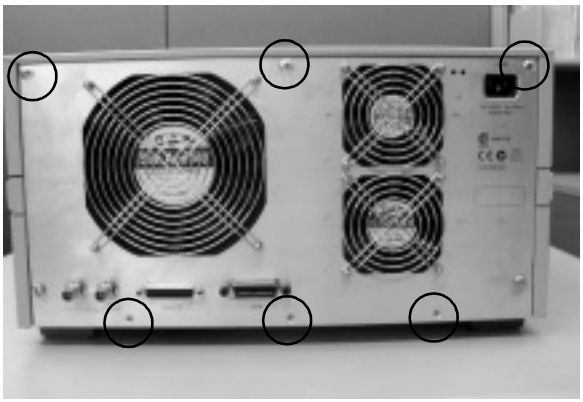
12. Remove the power supply unit with the handle.

Removing Connector Board

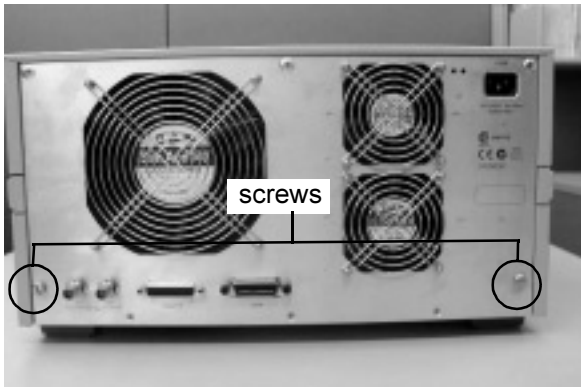
This section describes how to remove connector board.



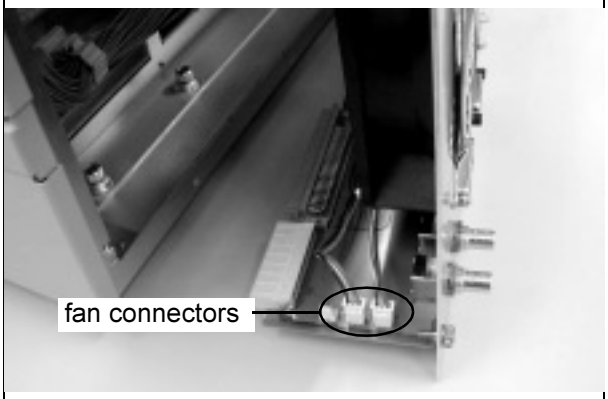
1. Turn off power, then disconnect the power cable.



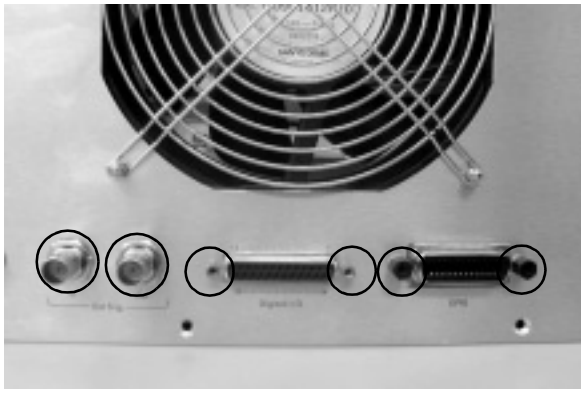
2. Loosen the six screws on the rear panel.



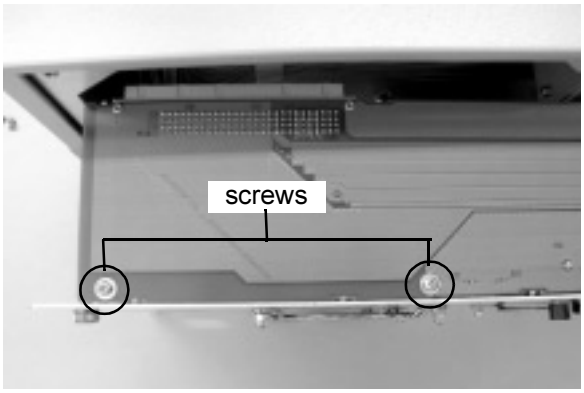
3. Gently loosen the two screws on the rear panel. The rear panel is moved forward by the screws.



4. Disconnect fan cables.



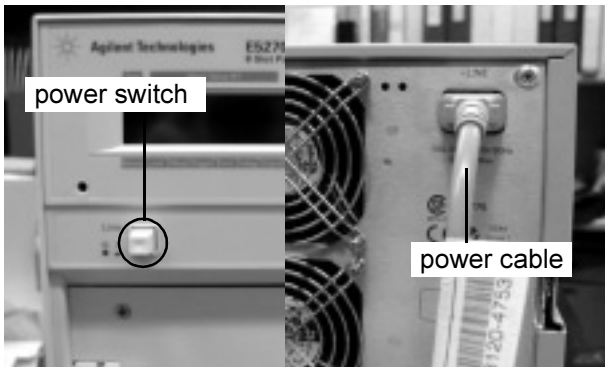
5. Loosen the screws for the GPIB, trigger, and digital I/O interfaces.



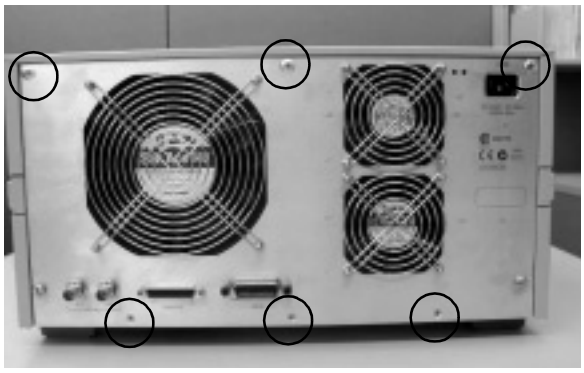
6. Loosen the screws on the backside of the interface board, and remove the connector board from the rear panel.

Removing Fans

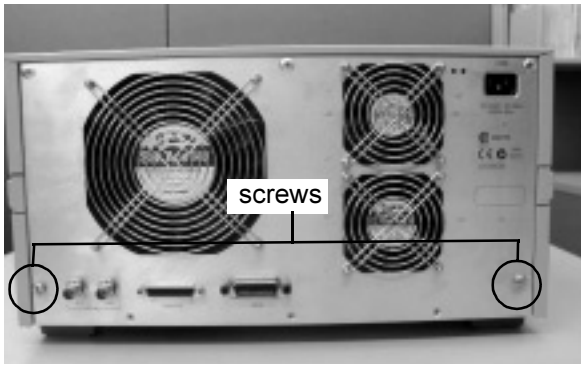
This section describes how to remove the fans.



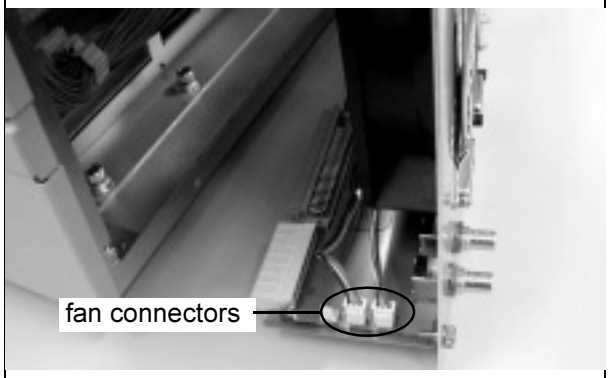
1. Turn off power, then disconnect the power cable.



2. Loosen the six screws on the rear panel.

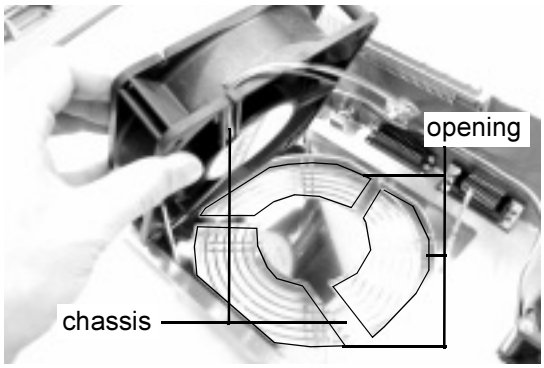


3. Gently loosen the two screws on the rear panel. The rear panel is moved forward by the screws.



4. Disconnect fan cables.

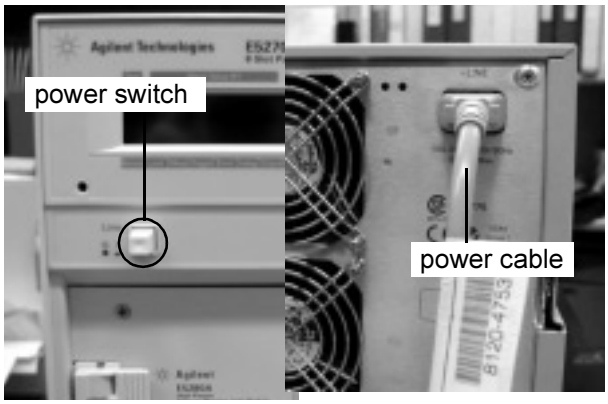
5. Loosen the screws on the fan, and remove the fan from the rear panel.



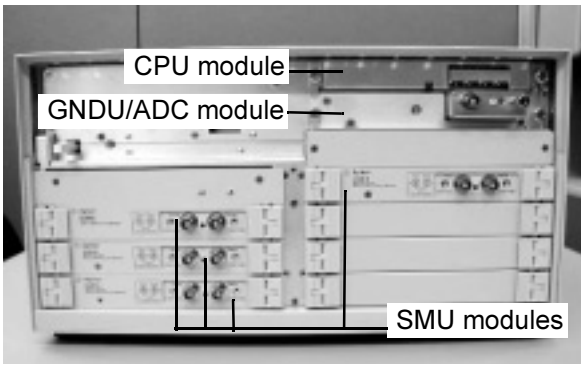
CAUTION When you reinstall the fan, fit the fan chassis to rear panel and do not block the chassis opening. Otherwise, the SMU may be damaged because of heating up.

Removing Motherboard

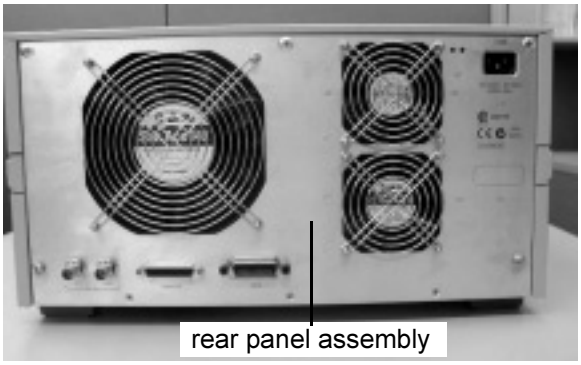
This section describes how to remove the motherboard.



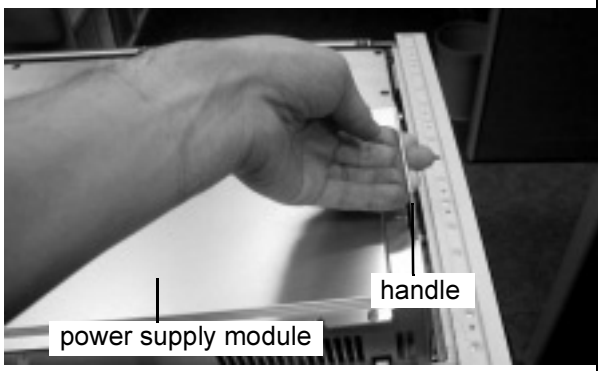
1. Turn off power, then disconnect the power cable.



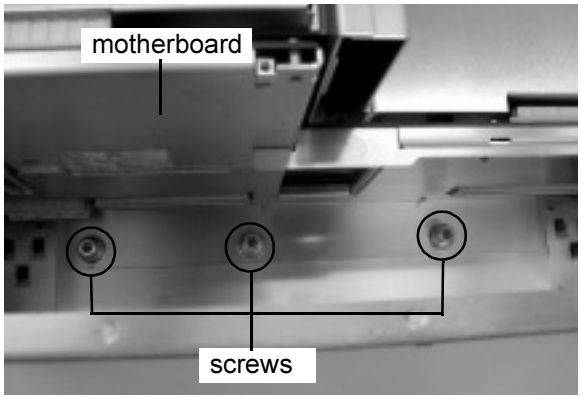
2. Remove SMU, GNDU/ADC, and CPU modules. See “Removing SMU Module”, “Removing GNDU/ADC Module”, and “Removing CPU Module”.



3. Remove the rear panel assembly. See “Removing Connector Board”.



4. Remove the power supply unit with the handle. See “Removing Power Supply Module”.



5. Loosen the screws.
6. Remove the motherboard assembly.

Updating Firmware

The firmware source and firmware update procedure will be available if the new revision firmware is released.

5 Replaceable Parts

This chapter describes the replaceable parts information, and consists of the following sections.

The tables in the sections below also contains the information which tests need to be performed when a part is replaced.

- “Replaceable Parts for E5270A”
- “Replaceable Parts for E5272A/E5273A”
- “Consumable Parts for E5270A/E5272A/E5273A”
- “Accessories”

For the replacement procedure, see Chapter 4, “Replacement Procedure”.

Replaceable Parts for E5270A

Table 5-1 Agilent E5270A replaceable parts

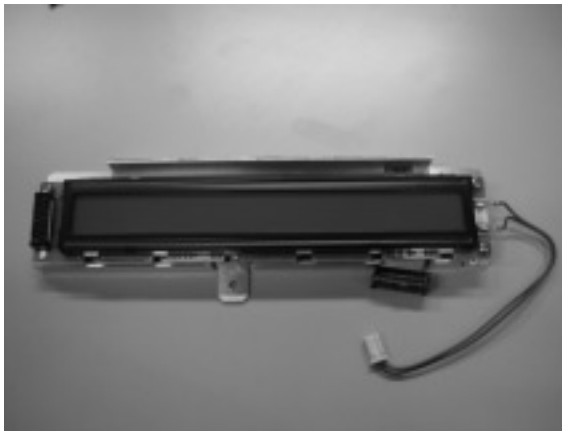
New part number (exchange part number)	Quantity	Description	PV tests and adjustments
3160-4151	1	Fan, large	All PV
3160-4152	1	Fan, small	All PV
E5270-60002	1	Motherboard	All PV Diagnostics (GPIB, digital I/O, trigger in/out)
E5270-60012 (E5270-69012)	1	Power supply module	All PV
E5270-61002	1	LCD	Self-test Visual check
E5270-66502	1	CPU module	Self-test All diagnostics
E5270-66503	1	Front board	Self-test Diagnostics (key, HV LED)
E5270-66504	1	Connector board	Self-test Diagnostics (GPIB, digital I/O, trigger in/out)
E5270-66505	1	GNDU/ADC module	ADC calibration All PV
E5280-61001 (E5280-69001)	Up to 4	HPSMU module	SMU calibration PV for the exchanged SMU module
E5280-66501 (E5280-69501)	Up to 8	MPSMU module	SMU calibration PV for the exchanged SMU module

Table 5-2 Agilent E5270A replaceable parts: pictures

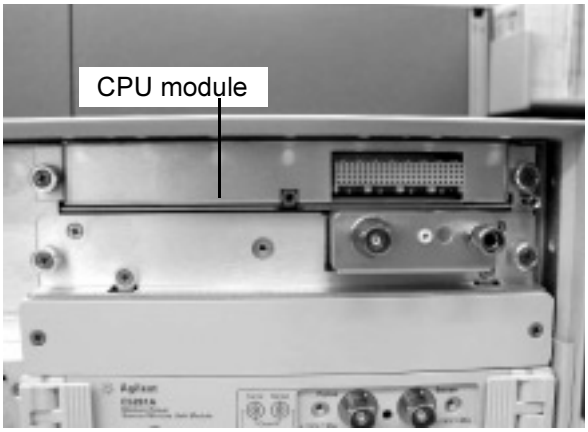
1. Fan, large; 3160-4151
2. Fan, small; 3160-4152

3. Motherboard; E5270-60002

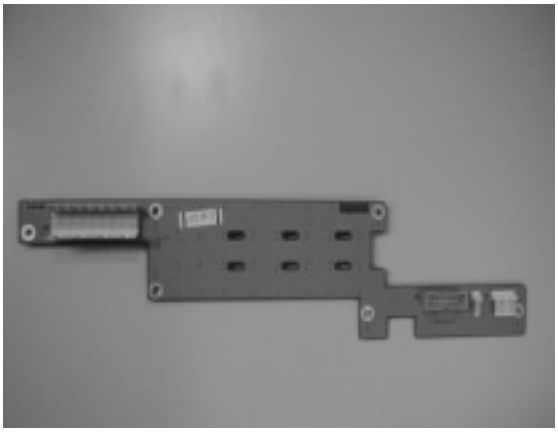
4. Power supply module; E5270-60012 (E5270-69012)



5. LCD assembly; E5270-61002

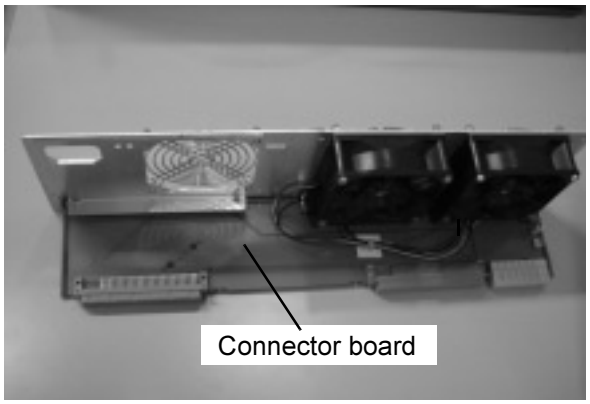


6. CPU module; E5270-66502

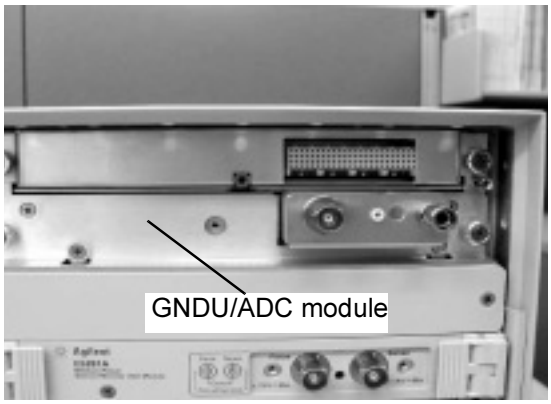


7. Front board; E5270-66503

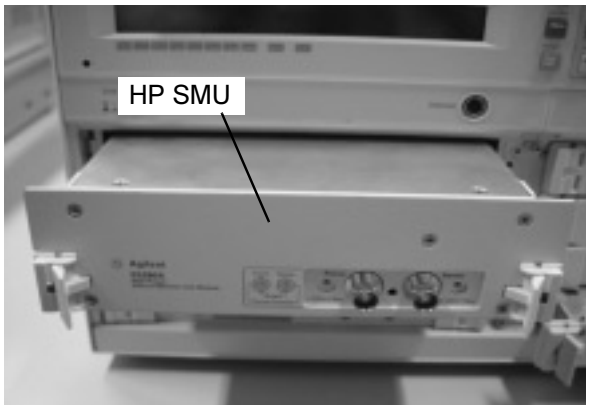
Table 5-2 Agilent E5270A replaceable parts: pictures



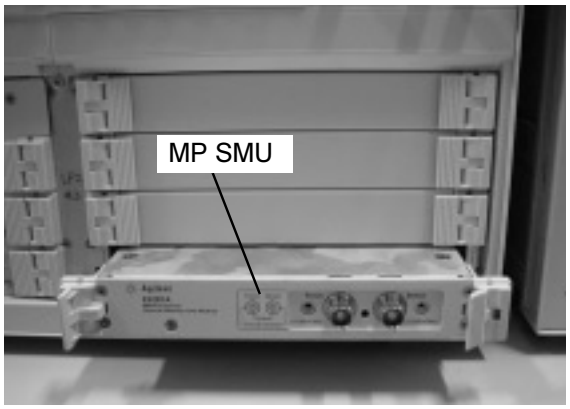
8. Connector board; E5270-66504



9. GNDU/ADC module; E5270-66505



10. HPSMU module; E5280-61001 (E5280-69001)



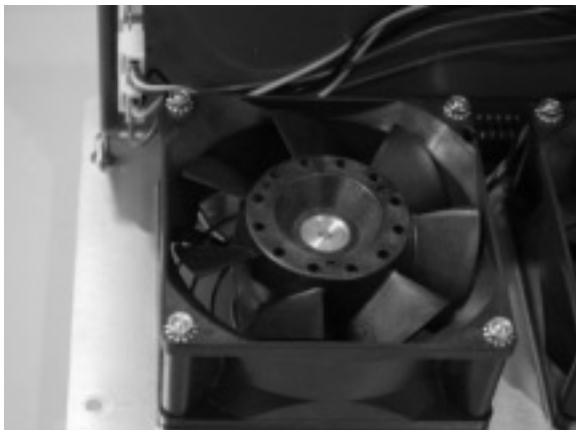
11. MPSMU module; E5280-66501 (E5280-69501)

Replaceable Parts for E5272A/E5273A

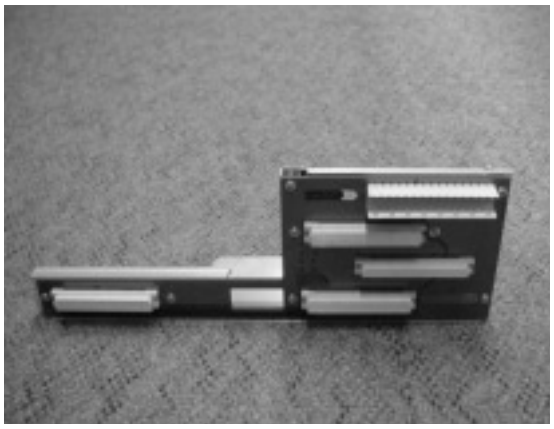
Table 5-3 Agilent E5272A/E5273A replaceable parts

New part number (exchange part number)	Quantity	Description	PV tests and adjustments
3160-4152	2	Fan, small	All PV
E5270-60002	1	Motherboard	All PV Diagnostics (GPIB, digital I/O, trigger in/out)
E5271-61012 (E5271-69012)	1	Power supply module	All PV
E5270-61002	1	LCD	Self-test Visual Check
E5270-66502	1	CPU module	Self-test All diagnostics
E5270-66503	1	Front board	Self-test Diagnostics (key, HVLED)
E5270-66504	1	Connector board	Self-test Diagnostics (GPIB, digital I/O, trigger in/out)
E5270-66505	1	GNDU/ADC module	ADC calibration All PV
E5280-61001 (E5280-69001)	Up to 1	HPSMU module	SMU calibration PV for the exchanged SMU
E5280-66501 (E5280-69501)	Up to 2	MPSMU module	SMU calibration PV for the exchanged SMU

Table 5-4 Agilent E5272A/E5273A replaceable parts: pictures



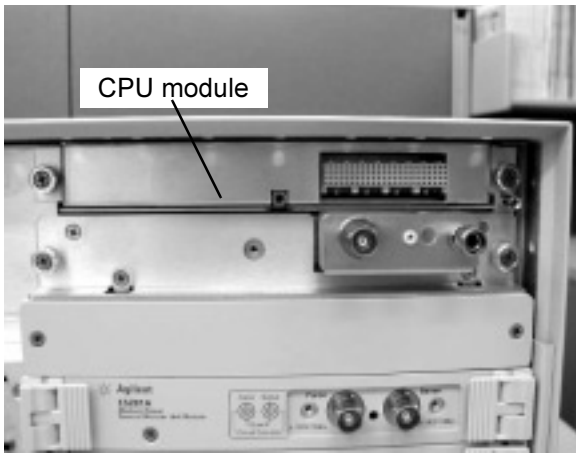
1. Fan, small; 3160-4152



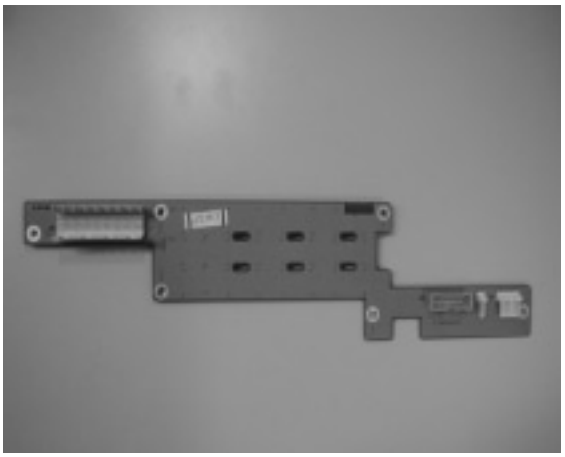
2. Motherboard; E5270-6002

3. Power supply module; E5271-61012 (E5271-69012)

4. LCD assembly; E5270-61002

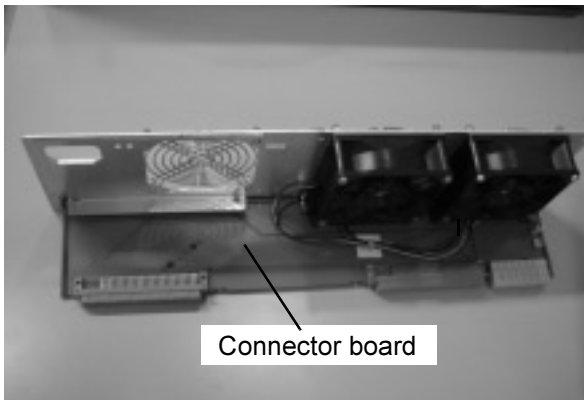


5. CPU module; E5270-66502

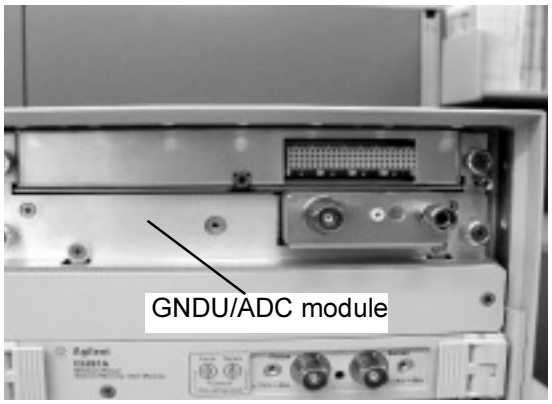


6. Front board; E5270-66503

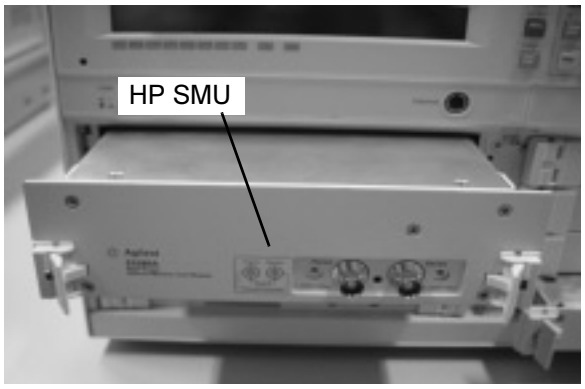
Table 5-4 Agilent E5272A/E5273A replaceable parts: pictures



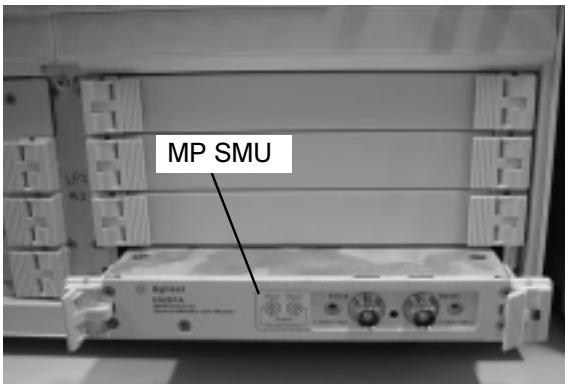
7. Connector board; E5270-66504



8. GNDU/ADC module; E5270-66505



9. HPSMU module; E5280-61001 (E5280-69001)



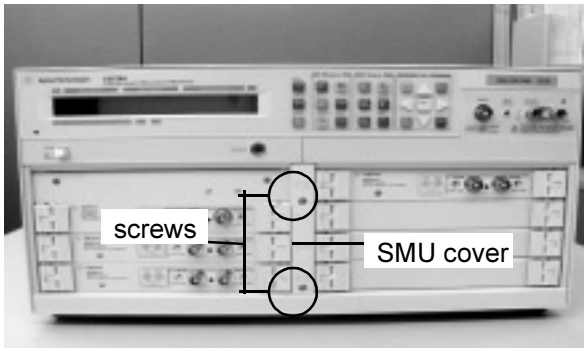
10. MPSMU module; E5280-66501 (E5280-69501)

Consumable Parts for E5270A/E5272A/E5273A

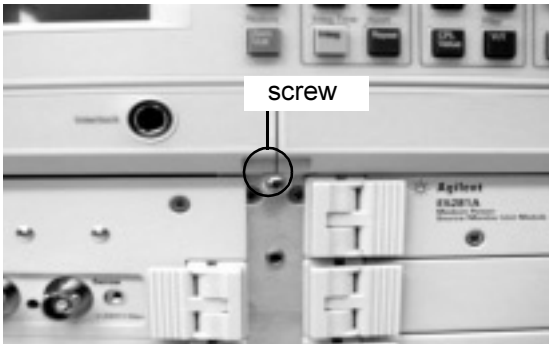
This section describes the consumable parts information.

NOTE The parts described in this chapter may not be set up as the support part. Check if the part is available from GTLS by looking into the database system such as e-Pal. If not available, contact HSTD for how to obtain the part.

Front panel consumable parts

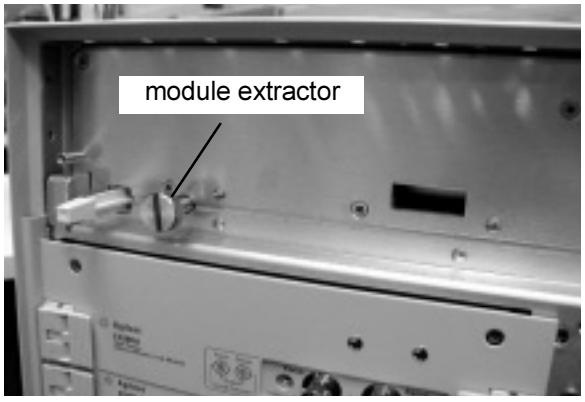


1. screw, M3L12L: 0515-1552
2. SMU cover for E5270A: E5270-40014
3. SMU cover for E5272A/E5273A: E5271-40014



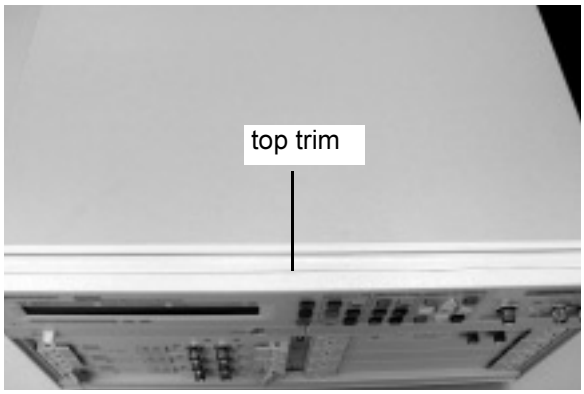
4. screw, M3L10: 0515-1551

5. shorting bar: 5000-4206

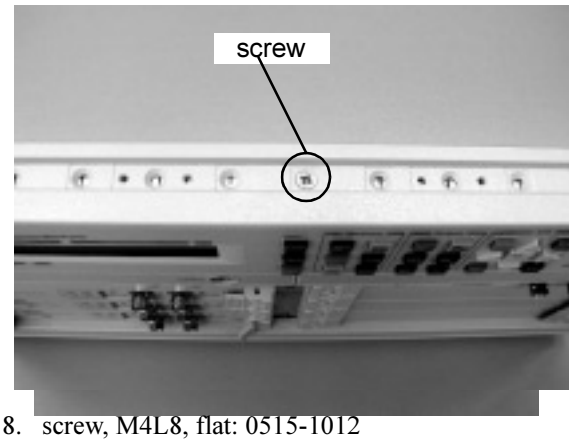


6. module extractor: 04155-24012

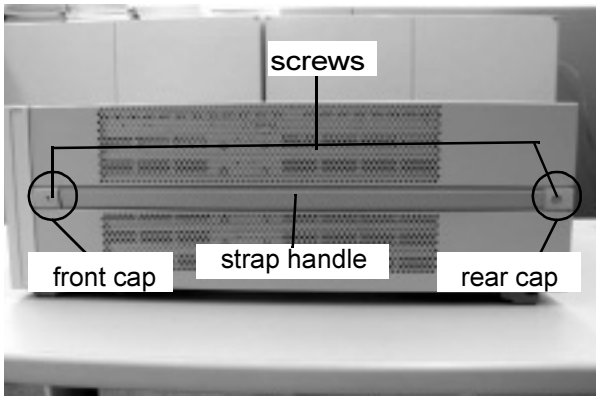
Top and side panel consumable parts



7. top trim: 5041-9176



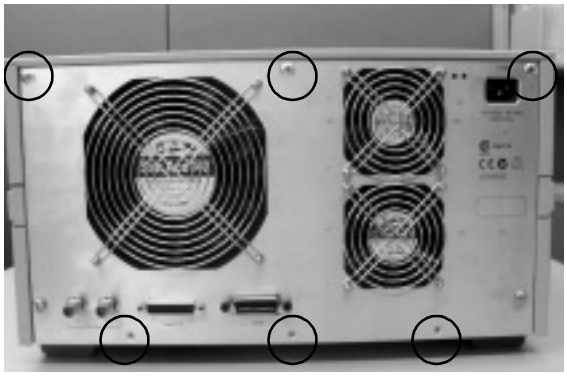
8. screw, M4L8, flat: 0515-1012



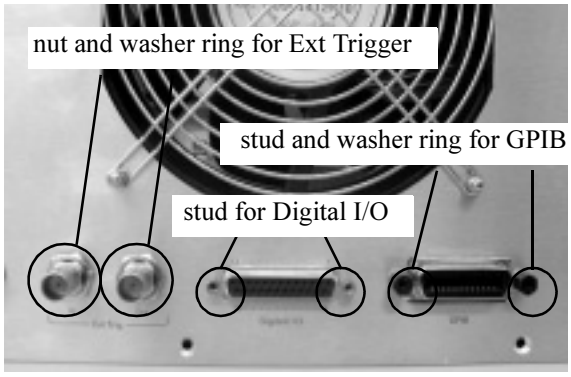
9. screw, M5: 0515-1384
10. strap handle:5063-9211
11. front cap: 5041-9186
12. rear cap: 5041-9187

13. top cover: E5270-04003

Rear and bottom side consumable parts



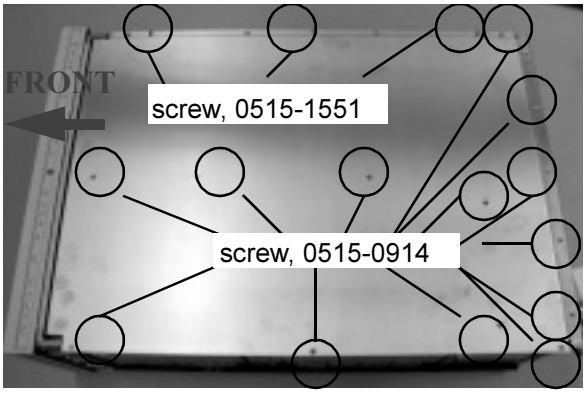
14. screw, M3L4, flat: 0515-1076



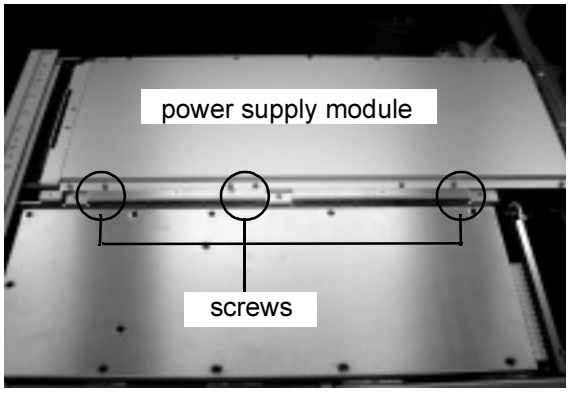
15. nut (for Ext Trigger): 2950-0054
16. washer ring (for Ext Trigger): 2190-0054
17. stud (for Digital I/O): 0380-3070
18. stud (for GPIB): 0380-0643
19. washer ring (for GPIB)2190-0577

20. foot: 5041-9167
21. foot lock: 5041-9168
22. tilt stand: 1460-1345

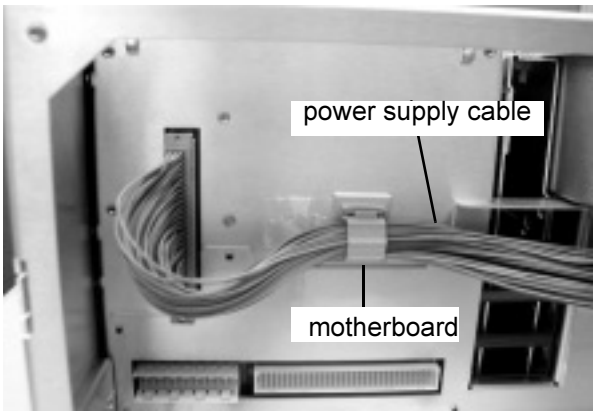
Inside of the frame consumable parts



1. screw, M3L10: 0515-1551
2. screw, M3L6, flat: 0515-0914

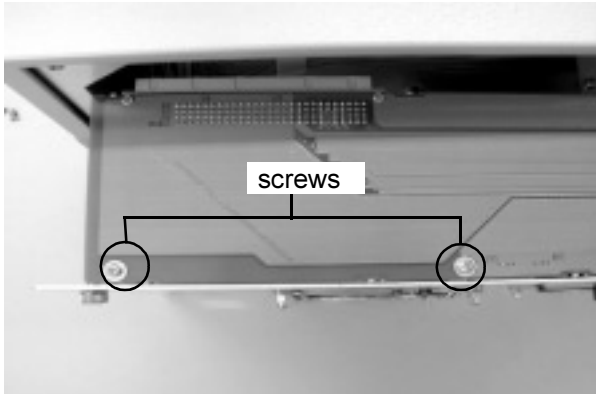


3. screw, M3L10: 0515-1551



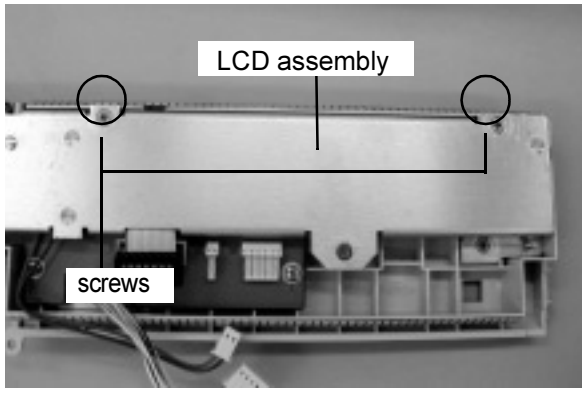
4. power supply cable for E5270A: E5270-61601
5. power supply cable for E5272A/E5273A: E5271-61601

6. power switch: E5270-40014
7. spring (for the power switch): 1400-2360

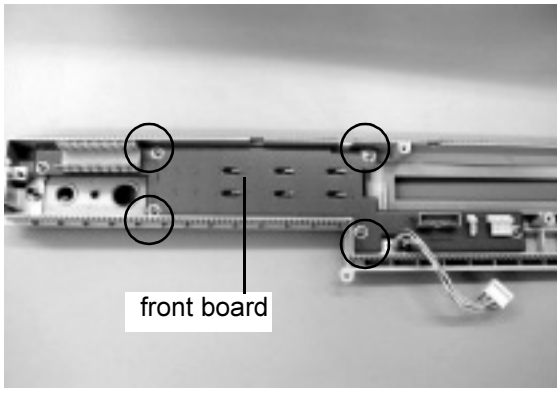


8. screw, M3L8: 0515-1550

9. nut with washer: 0535-0031



10. screw, M3L6, flat: 0515-0914



11. screw, M3L8: 0515-1550

12. rubber key: E5270-40010

Accessories

Connector plate (Agilent 16495H)

Figure 5-1 Connector plate (Agilent 16495H) parts location (1 of 2)

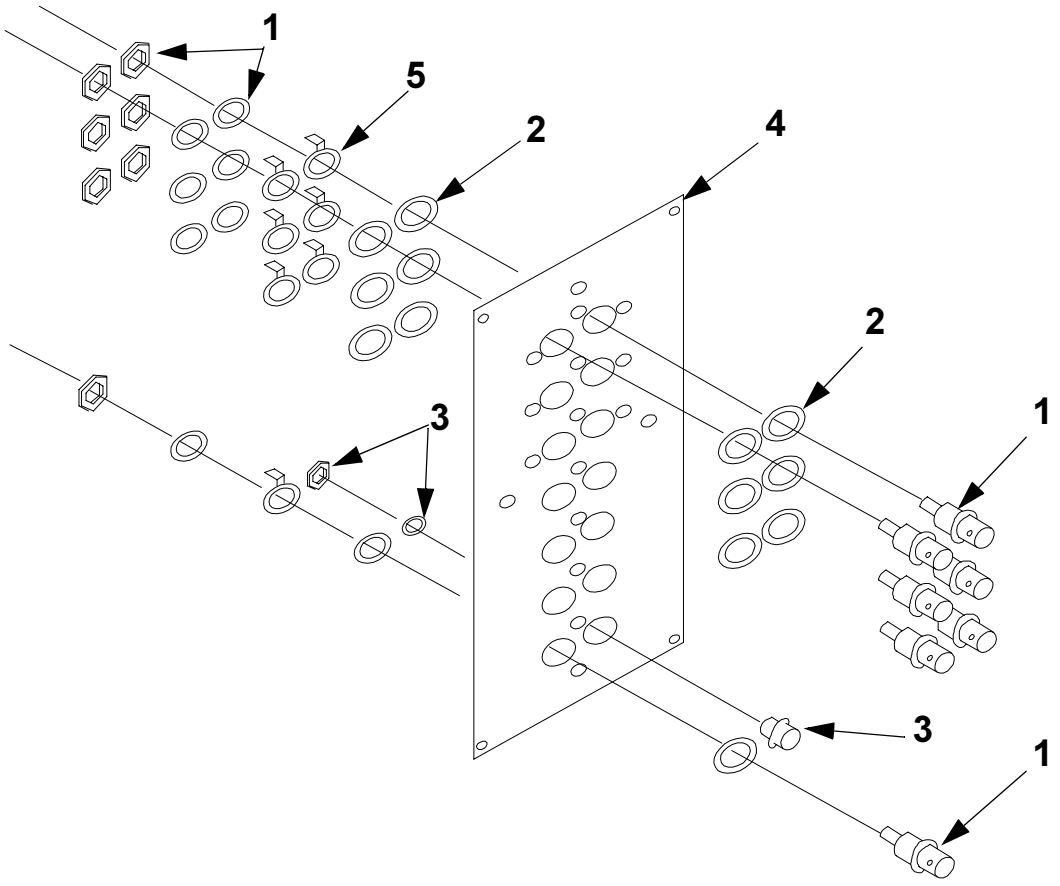


Table 5-5 Connector plate (Agilent 16495H) replaceable parts (1 of 2)

Reference designation	Part number (option 001)	Part number (option 002)	Quantity	Description
1	1250-2618	1250-2457	7	Triax connector
2	16495-40001	16495-40002	14	Insulator
3	1252-1419	⇐	1	Connector
4	16495-00313	16495-00315	1	Panel
5	04284-01211	5000-4218	7	Terminal lug

Figure 5-2 Connector plate (Agilent 16495H) parts location (2 of 2)

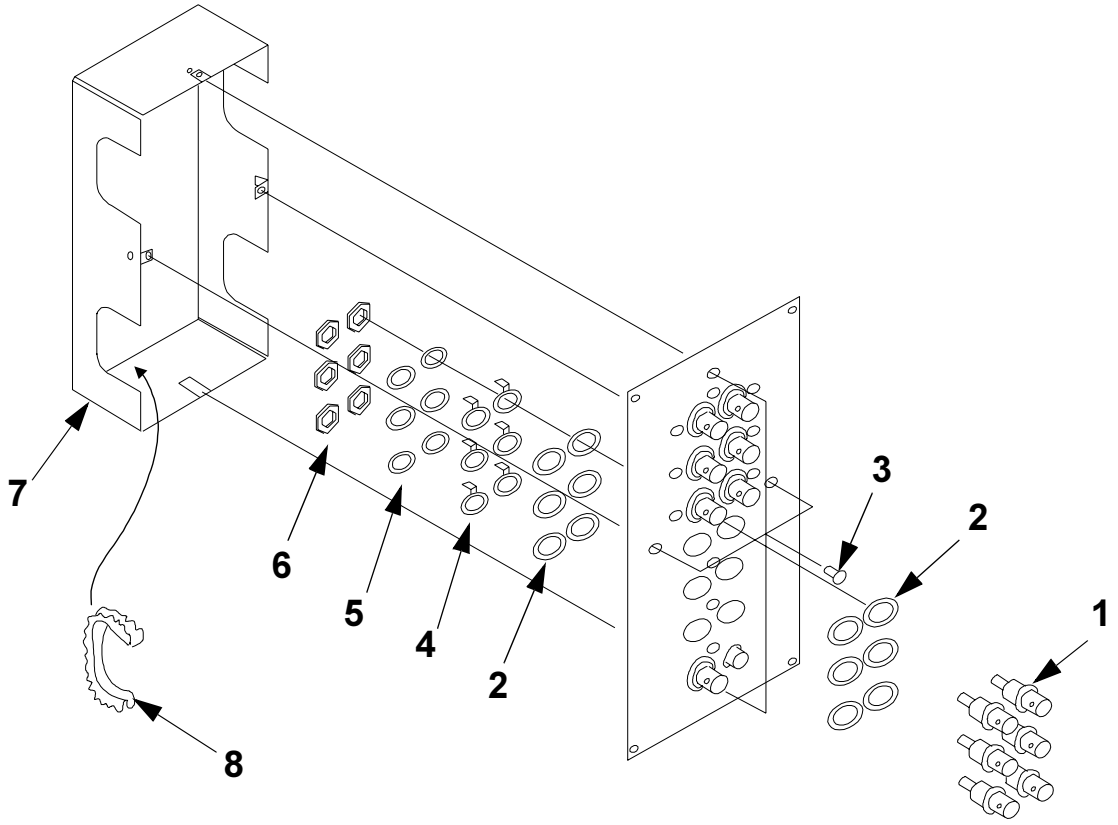


Table 5-6 Connector plate (Agilent 16495H) replaceable parts (2 of 2)

Reference designation	Part number (option 001)	Part number (option 002)	Quantity	Description
1	1250-2617	1250-0118	6	BNC connector
2	16495-40001	5040-0345	12	Insulator
3	–	0515-0914	4	M3 screw L6
4	04284-01211	0360-1190	6	Terminal lug
5	–	2190-0016	6	Washer lock
6	–	2950-0001	6	Nut
7	–	16495-04003	1	Cover
8	–	0400-0254	4	Edge guard (9 cm)

Connector Plate (Agilent 16495J)

Figure 5-3 Connector plate (Agilent 16495J) parts location (1 of 2)

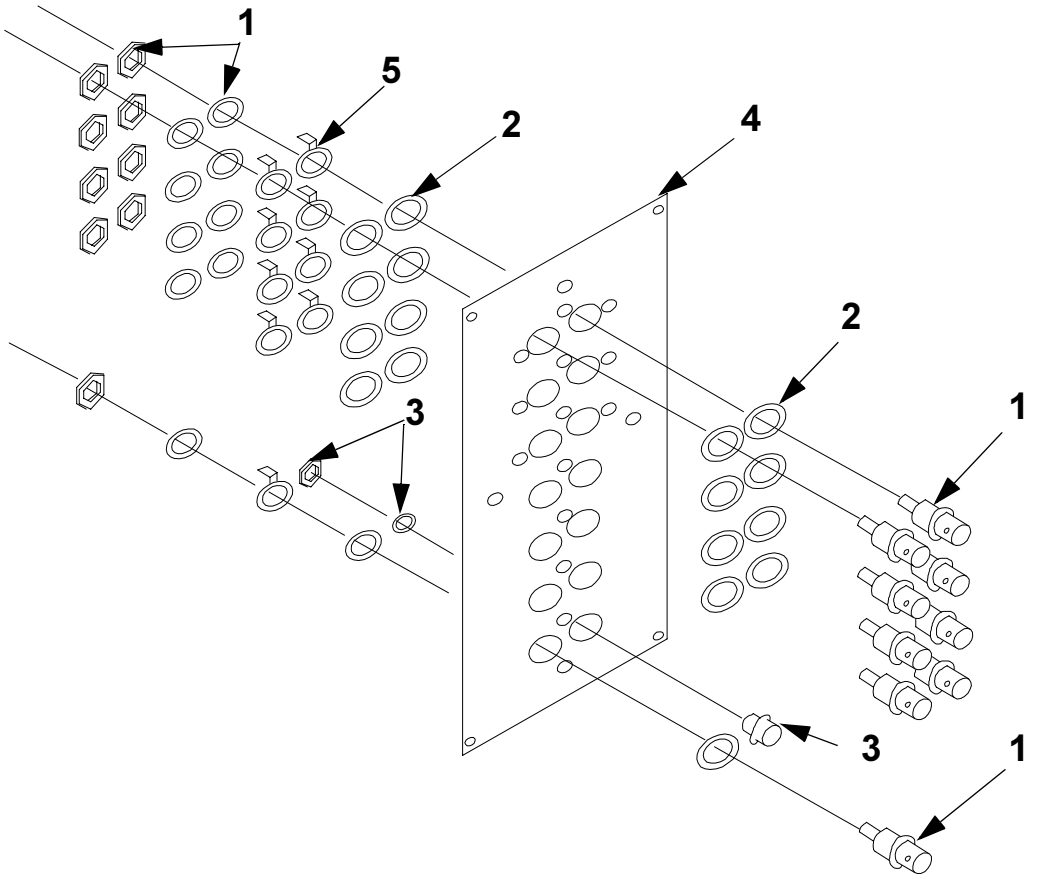


Table 5-7 Connector plate (Agilent 16495J) replaceable parts (1 of 2)

Reference designation	Part number (option 001)	Part number (option 002)	Quantity	Description
1	1250-2618	1250-2457	9	Triax connector
2	16495-40001	16495-40002	18	Insulator
3	1252-1419	⇐	1	Connector
4	16495-00314	16495-00316	1	Panel
5	04284-01211	5000-4218	9	Terminal lug

Figure 5-4 Connector plate (Agilent 16495J) parts location (2 of 2)

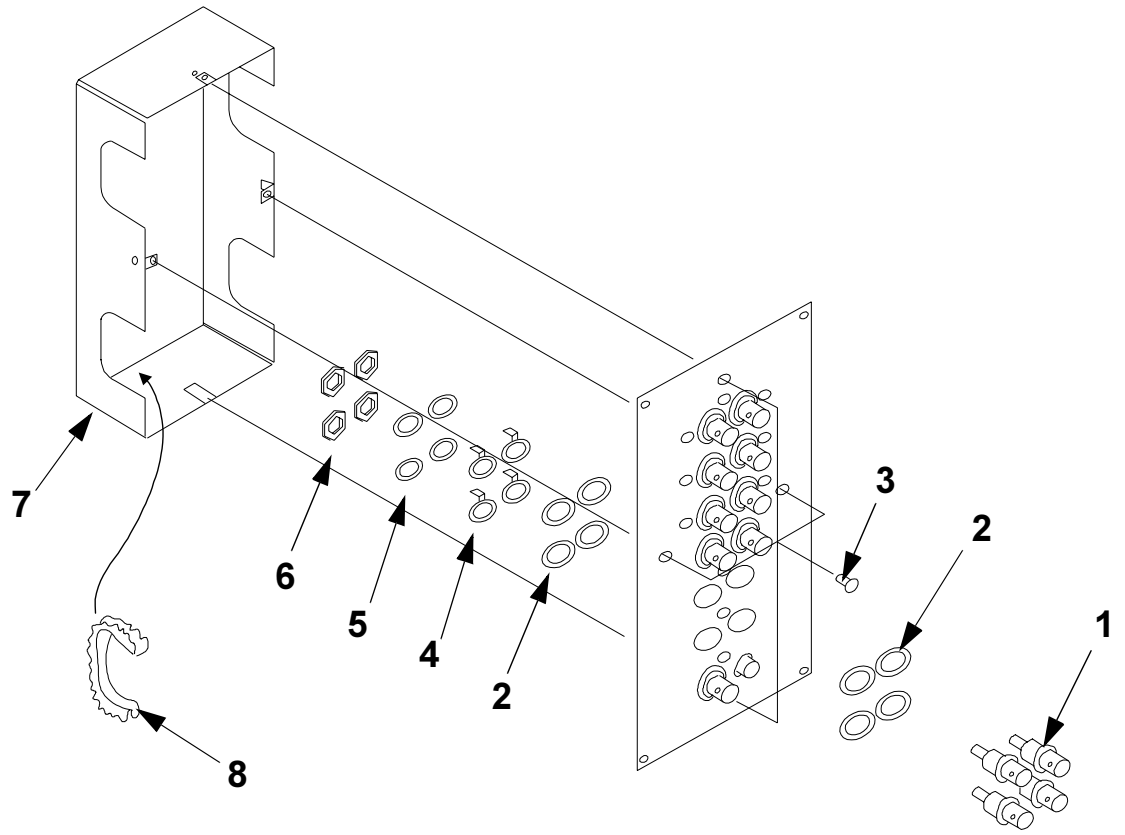


Table 5-8 Connector plate (Agilent 16495J) replaceable parts (2 of 2)

Reference designation	Part number (option 001)	Part number (option 002)	Quantity	Description
1	1250-2617	1250-0118	4	BNC connector
2	16495-40001	5040-0345	8	Insulator
3	–	0515-0914	4	M3 screw L6
4	04284-01211	0360-1190	4	Terminal lug
5	–	2190-0016	4	Washer lock
6	–	2950-0001	4	Nut
7	–	16495-04003	1	Cover
8	–	0400-0254	4	Edge guard (9 cm)

6 Theory of Operation

This chapter provides a simplified explanation of E5270A/E5272A/E5273A circuit operation to aid in troubleshooting them. Included are the following sections.

- “Overall Block Diagram”
- “Measurement Unit”
- “CPU, GNDU/ADC Board, LCD, and Front Board”
- “Power Supply”
- “Abnormal Condition Detectors”
- “External Instrument Control”

Overall Block Diagram

The following 3 figures show:

- Overall control and power destination diagram for the E5270A
- Overall control and power destination diagram for the E5272A/E5273A
- Overall measurement diagram for the E5270A/E5272A/E5273A

Figure 6-1 Overall control and power destination diagram for the Agilent E5270A

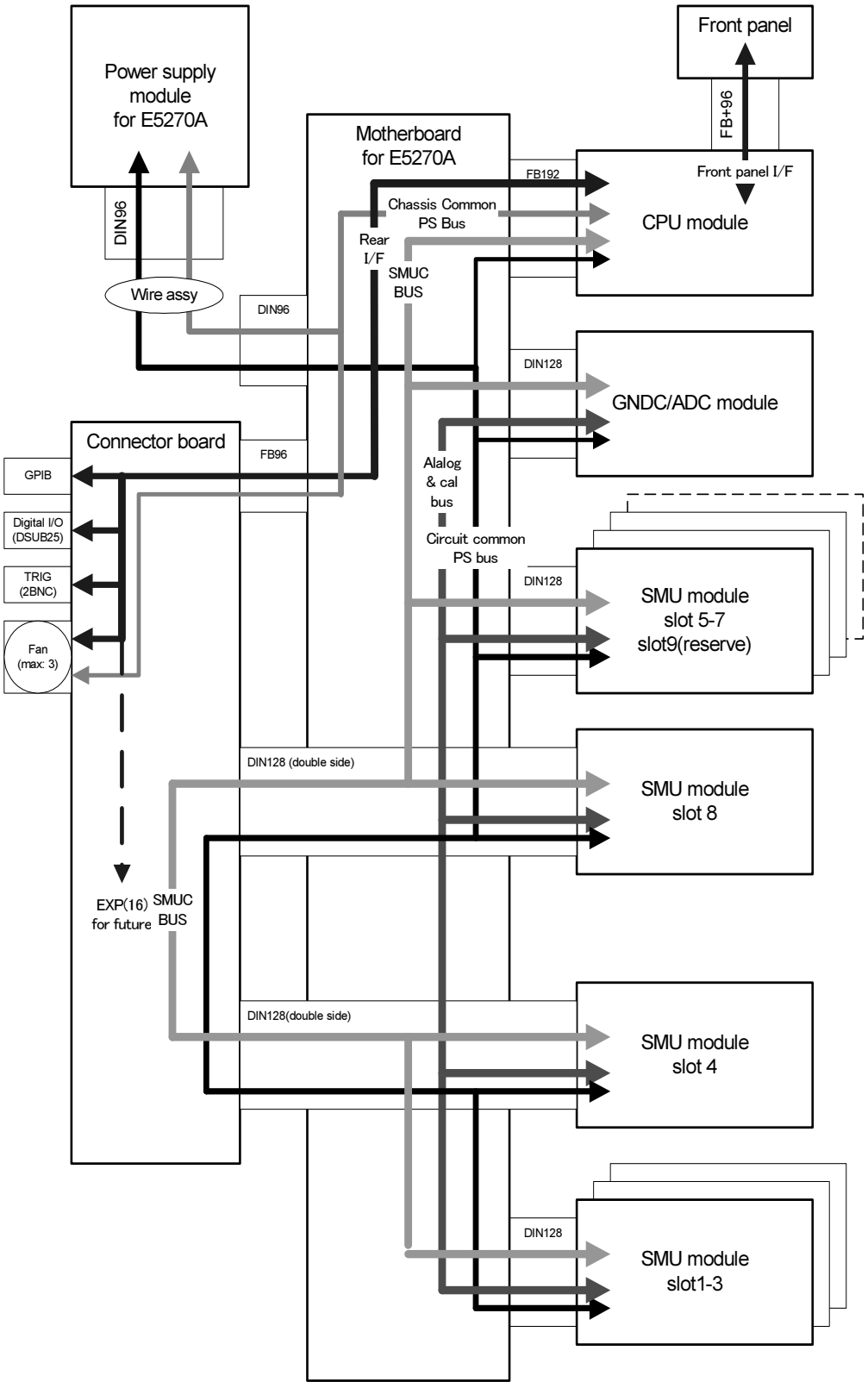


Figure 6-2 Overall control and power destination diagram for Agilent E5272A/E5273A

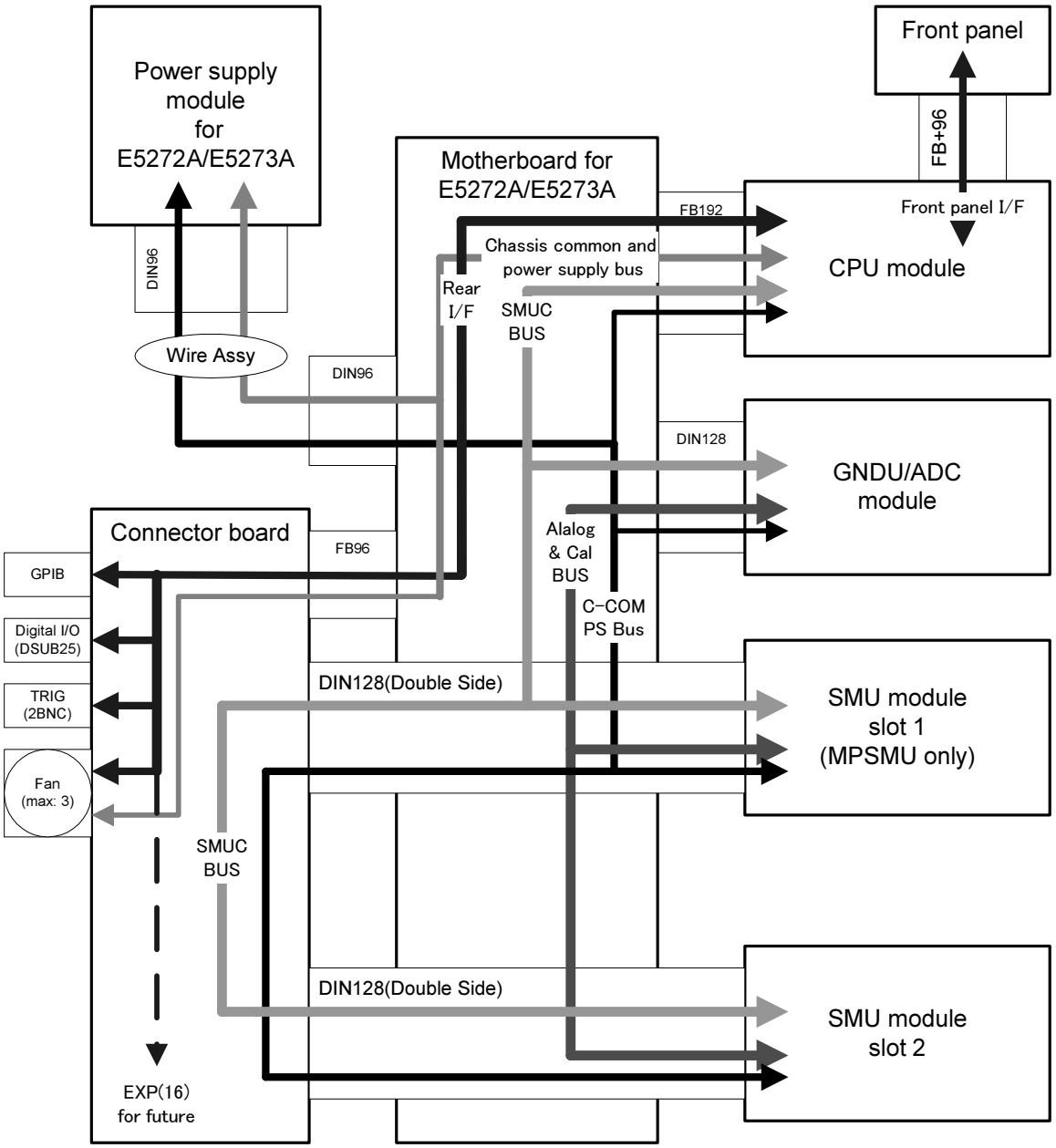
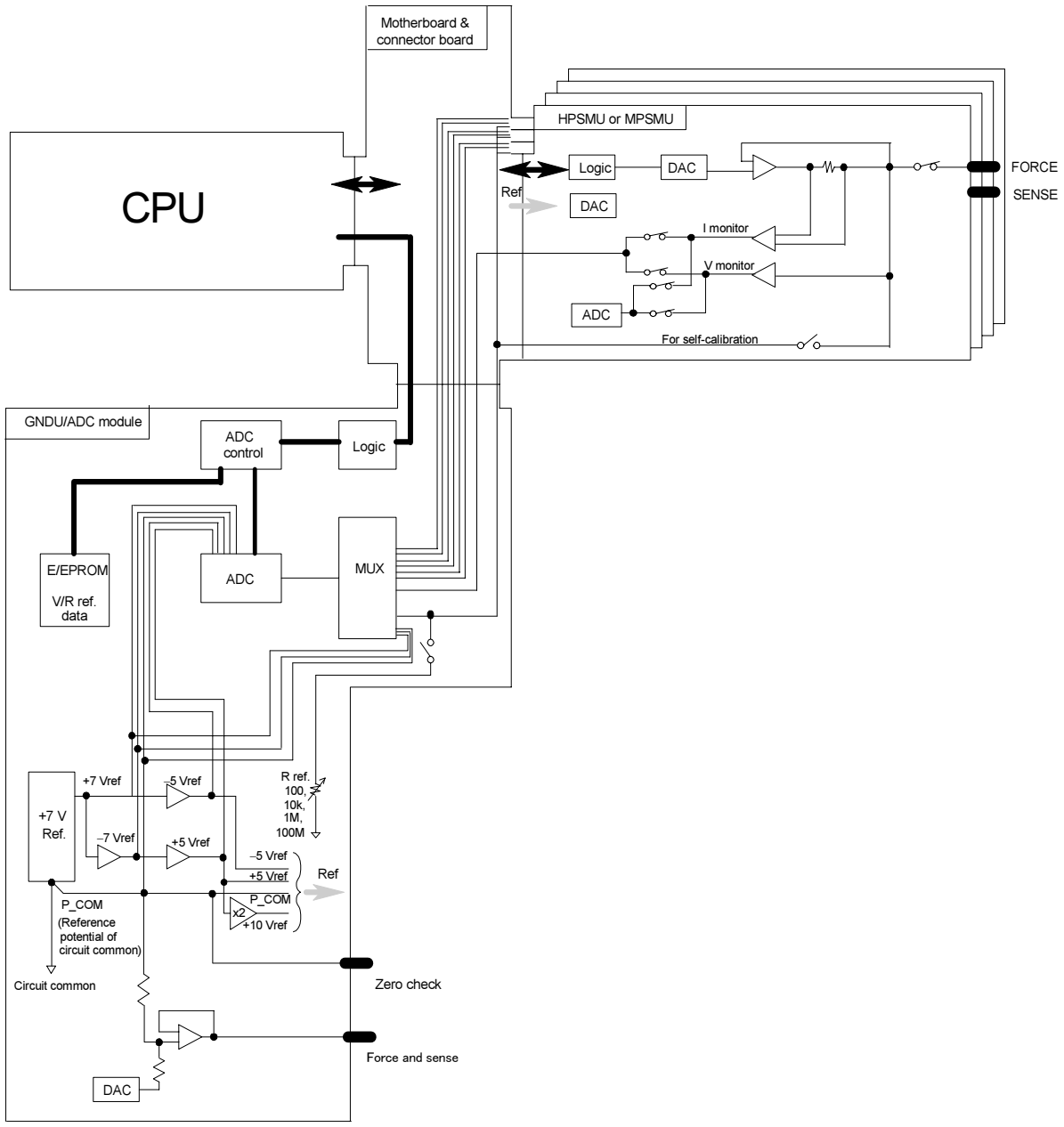


Figure 6-3 Overall measurement diagram for Agilent E5270A/E5272A/E5273A



Measurement Unit

This section provides a simplified explanation of the circuit operation of the following measurement units to help in troubleshooting.

MPSMU

One medium power source monitor unit is installed in the E5273A, two are installed in the E5272A and up to eight can be installed in the E5270A.

HPSMU

One high power source monitor unit is installed in the E5273A and up to four can be installed in the E5270A.

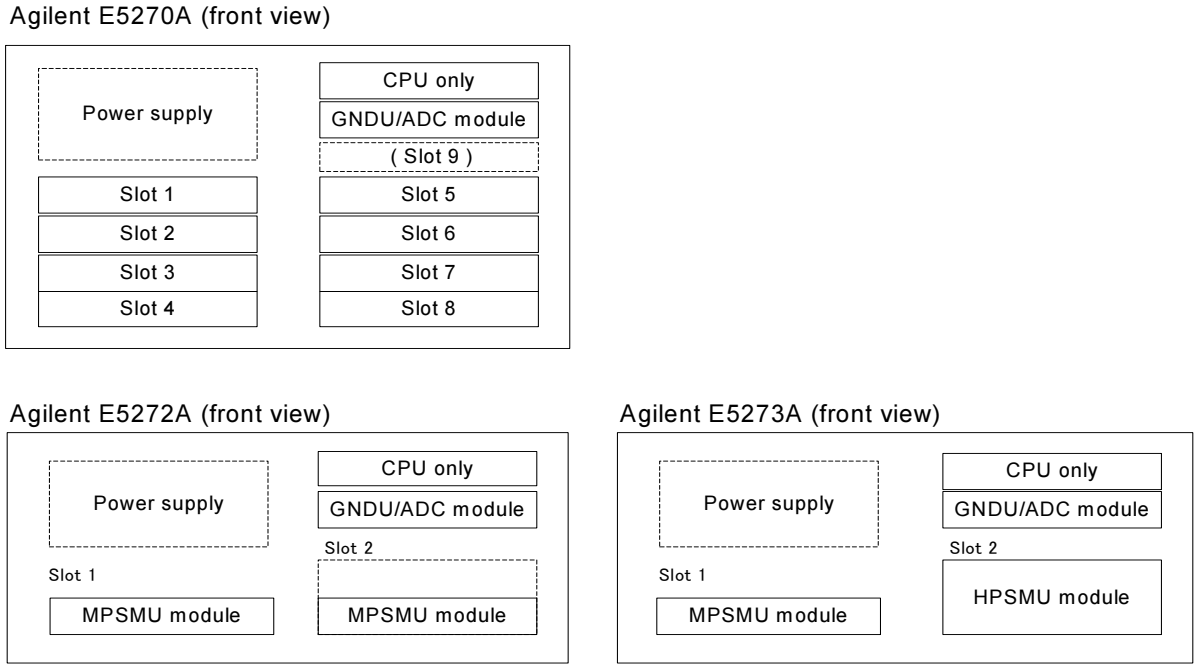
GNDU/ADC module

One GNDU/ADC module is installed in the E5270A, E5272A, and E5273A.

CPU module

One CPU module is installed in the E5270A, E5272A, and E5273A.

Figure 6-4 Measurement unit installable slots



NOTE

- In the E5273A, MPSMU can be installed in the slot 2 for troubleshooting purposes only.
- One HPSMU occupies two slots, and is connected to the motherboard using the connector of the bottom side slot.

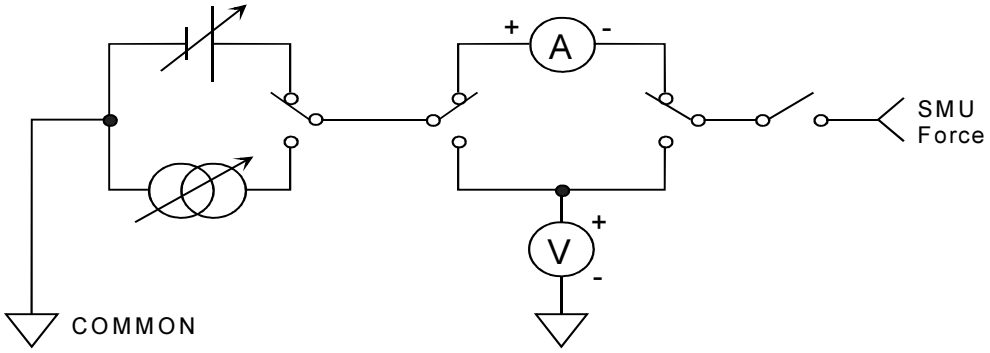
Source monitor unit (SMU)

The SMU can force a constant voltage, constant current, pulse voltage, or pulse current, and can measure a dc current or dc voltage. Only one SMU can be set to the pulsed source.

Figure 6-5 is a simplified SMU circuit diagram. The SMU has the following three modes:

- voltage force and current monitor mode (VFIM)
- current force and voltage monitor mode (IFVM)

Figure 6-5 Simplified SMU circuit diagram



The following two types of SMUs are available for the E5270A/E5272A/E5273A:

Medium power SMU (MPSMU)

The E5270A can have up to eight MPSMUs, the E5272A has two, and the E5273A has one. The MPSMU can force and measure up to ±100 V or ±200 mA. The maximum output power is 4 W at 20 V range and 2 W at 40 V and 100 V ranges.

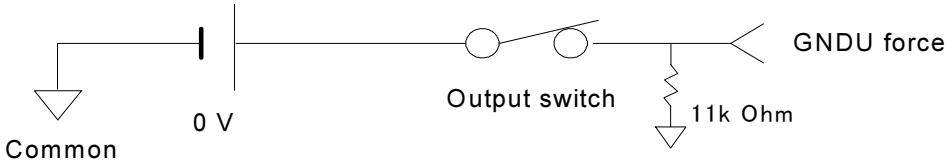
High power SMU (HPSMU)

The HPSMU is for the E5270A and E5273A. The E5270A can have up to four HPSMUs, and the E5273A has one. The HPSMU can force and measure up to ±200 V or ±1 A. The maximum output power is 20 W at 20 V and 40 V ranges, 12.5W at 100 V range, and 10 W at 200 V range.

Ground unit (in GNDU/ADC module)

The ground unit is a 0 V constant voltage source, used for the reference of the measurement ground. Also, the GNDU can sink up to ±4 A in the E5270A and ±2.2 A in the E5272A and E5273A, so it is effective for using the HPSMU. Figure 6-6 is a simplified circuit diagram of GNDU.

Figure 6-6 Simplified GNDU circuit diagram

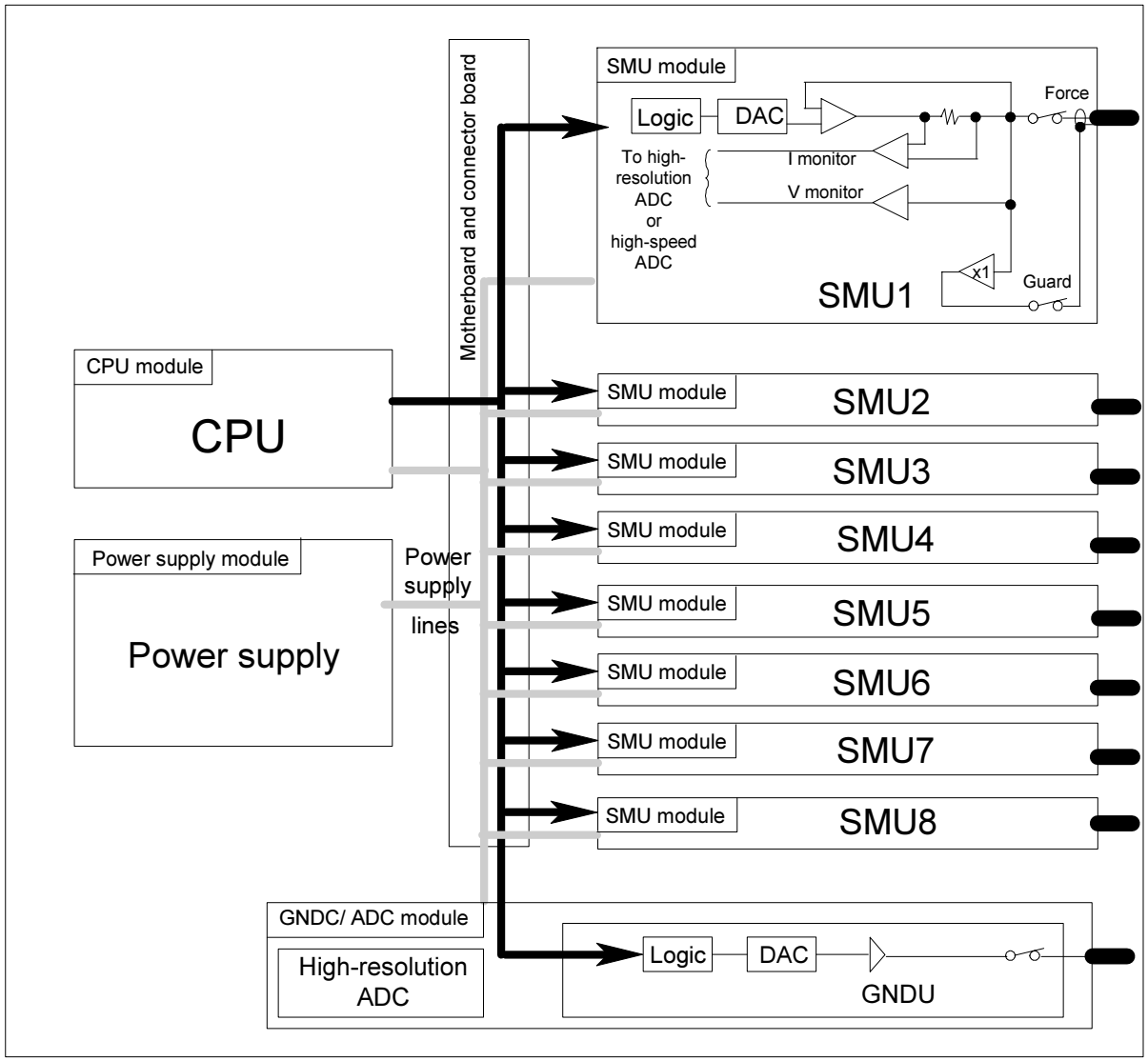


Output diagram

In the E5270A/E5272A/E5273A, each measurement-unit module (SMU and GNDU) includes all circuits for the output. That is, each module has everything from the digital analog converter (DAC) to the output terminal. Therefore, the output circuit of each module is independent of the other modules.

Figure 6-7 is output flow diagram. The CPU (CPU module) controls all measurement-unit modules, and the CPU module is connected to each measurement-unit through the motherboard and the connector board.

Figure 6-7 Output flow diagram



Measurement diagram

There are 2 kinds of ADCs, a high-resolution ADC on GNDU/ADC module and the high-speed ADCs on the SMU modules. The inputs to the high-resolution ADC are switched by the multiplexer on the SMU module. When you perform multi-channel measurements by using the high-resolution ADC, the timing for each channel is different. The time difference consists of the measurement integration time and measurement range change time by auto ranging. Figure 6-8 shows an example of the measurement timing for multi-channel measurement.

Figure 6-8 Multi-channel measurement in output sweep

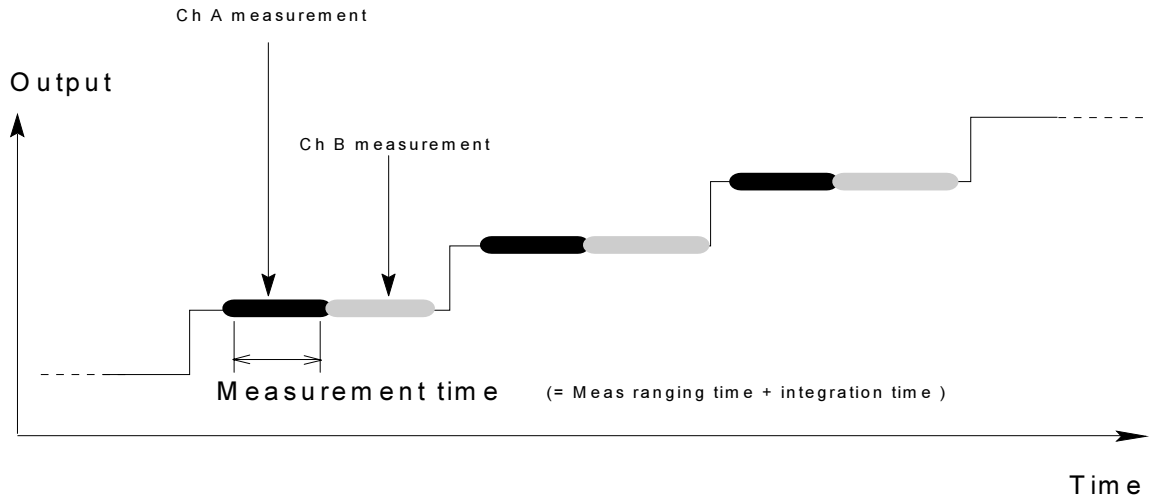
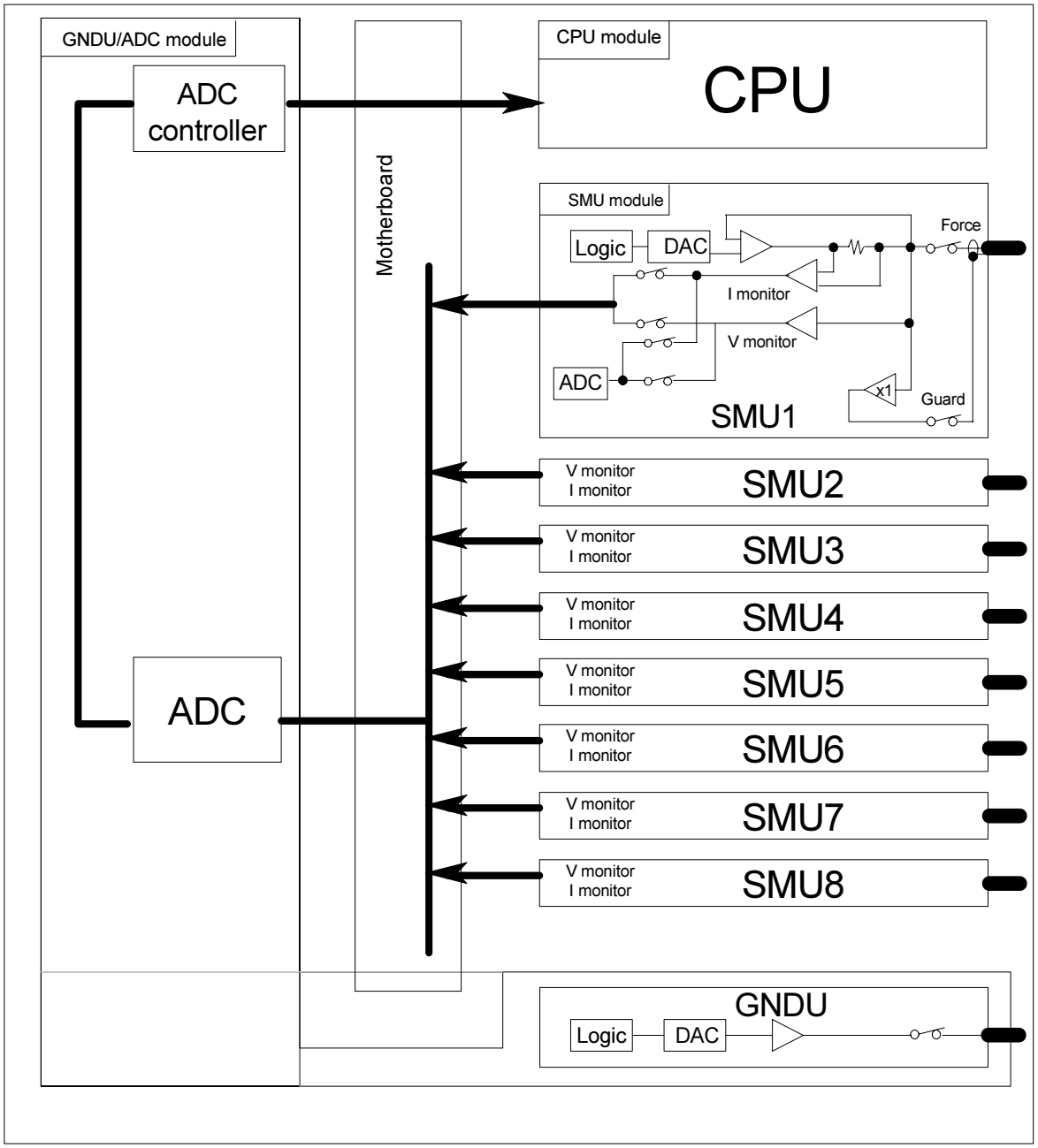


Figure 6-9 is the measurement flow diagram. The monitor amplifier in each measurement-unit module normalizes the input voltage/current to 0 to ±8 and the polarity is reversed for the voltage measurement. The normalized voltage is sent to the GNDU/ADC module. For example, if the SMU voltage measurement range is 100 V and the ADC-converted value is 8 V, the measurement voltage is −100 V.

The input to the high-speed ADC is normalized to 0 to ±8 also in the same manner.

Figure 6-9 Measurement flow diagram



Auto ranging measurement

The SMU unit searches for and measures at the range that provides the highest resolution as follows:

- V measurement

  The unit changes ranges (up or down one range at a time) until the measurement value is between 100% of the lower voltage range and 110% of the present range; then the unit performs the measurement.

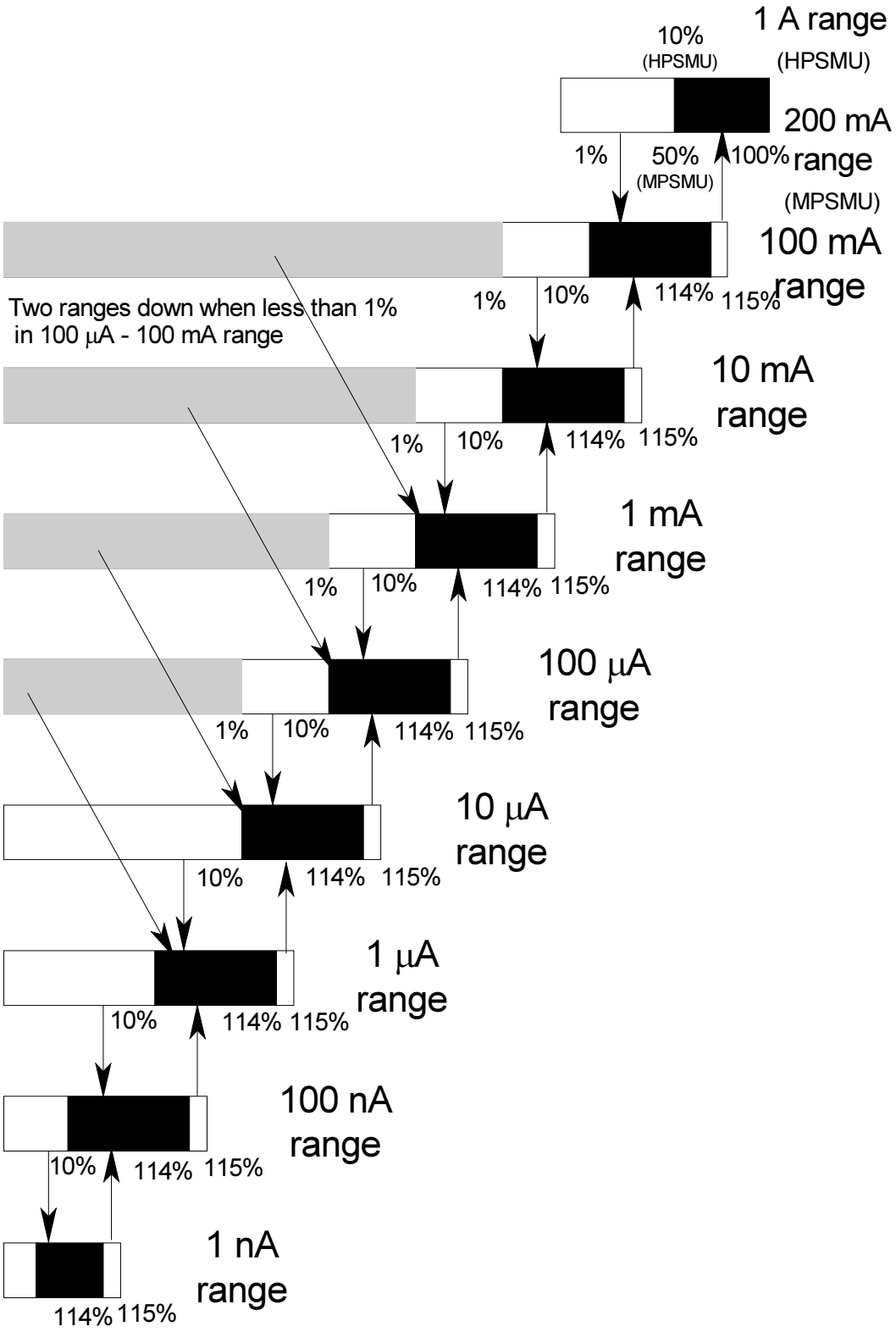
- I measurement

  The unit changes ranges (up or down one range at a time) until the measurement value is between 10% and 114% of the range; then the unit performs the measurement.

  Exception: If the present range is 100 μA to 100 mA and the measurement value is less than 1% of the present range, the range changes down two ranges instead of one range.

  If the unit is MPSMU and the present range is 200 mA, the unit changes to 100 mA range when the measurement value is less than 50% of the range.

Figure 6-10 SMU current measurement auto ranging



SMU current self-calibration path (R reference)

There are five reference resistors on the ADC board: 5Ω, 100Ω, 10Ω, 1 MΩ, and 100 MΩ resistors. These resistors are used for the SMU current self-calibration. The following shows the destination of each reference resistor.

100 Ω: For 100 mA and 1 A ranges self-calibration.

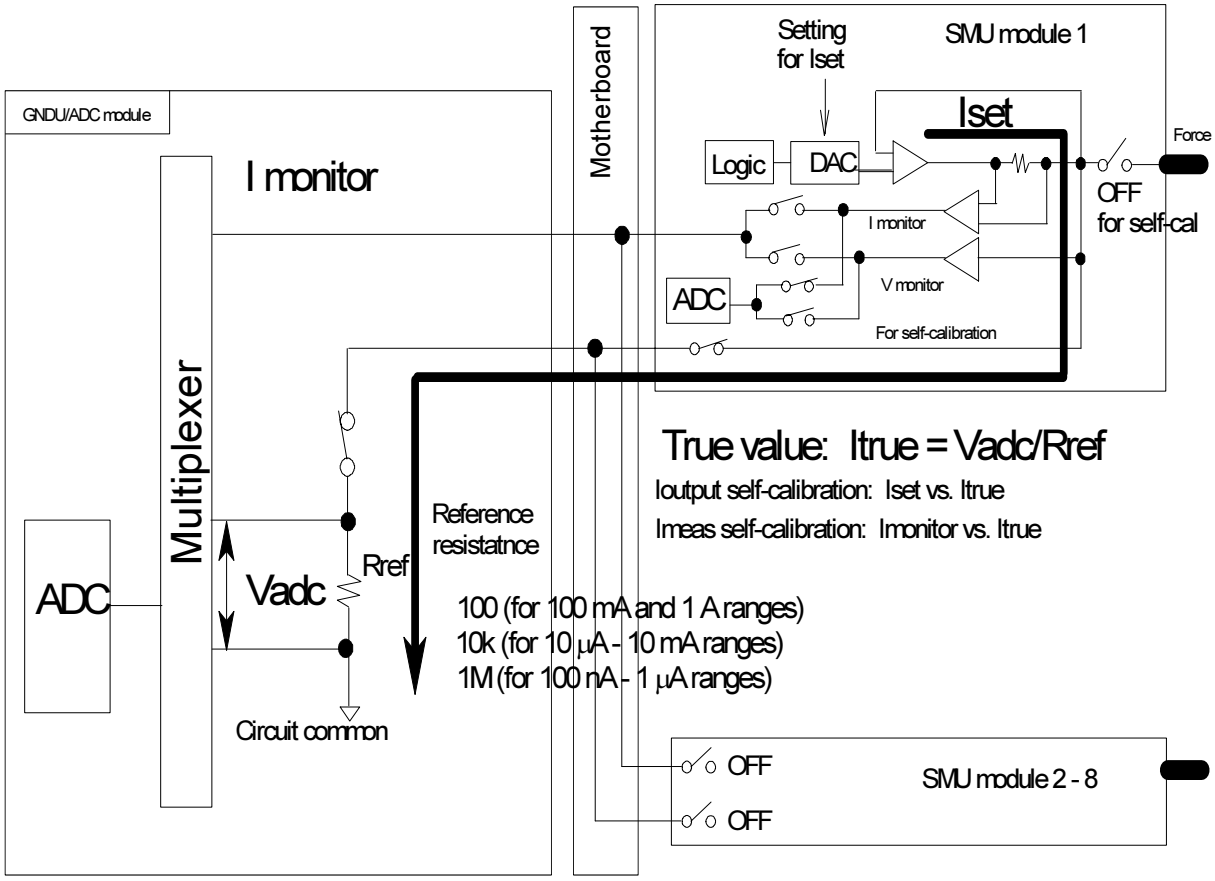
10 kΩ: For 10 μA to 10 mA ranges self-calibration.

1 MΩ: For 100 nA to 1 μA ranges self-calibration.

5Ω, 100 MΩ: For enhancement.

Figure 6-11 is the simplified circuit diagram for the SMU current output/measurement self-calibration path.

Figure 6-11 SMU current output/measurement self-calibration path



Self-calibration flow

The current output self-calibration is done in the following order:

1. SMU forces a current (Iset) to R reference whose value is known by calibration, through the self-calibration bus.
2. ADC measures the Vadc, which is the voltage of R reference.
3. CPU calculates the following, which is the true value of Iset.

$$\frac{Vadc}{Rref}$$

The current measurement self-calibration is done in the following order:

1. SMU forces a current (Iset).
2. SMU measures the current (Imonitor).
3. ADC measures the Vadc.
4. CPU calculates the following, which is the true value of I monitor.

$$\frac{Vadc}{Rref}$$

Self-calibration path (measurement bus & self-calibration bus)

The self-calibration is performed by forcing the output internally and measuring the output. During the self-calibration, the outputs are not forced outside because all output switches are set to off.

When you perform the self-test, the self-calibration is also performed. Also the self-calibration is a kind of test because there are limits of measurement value for self-calibration.

Self-calibration bus

The self-calibration bus connects the output of measurement unit and the ADC directly (without monitor amplifier). This is for accurate self-calibration.

All measurement units have the self-calibration bus.

Maximum voltage is limited to 10 V because the maximum ADC input is 10 V. To self-calibrate the voltages greater than 10 V, the normal measurement bus (V/I Monitor lines) is used.

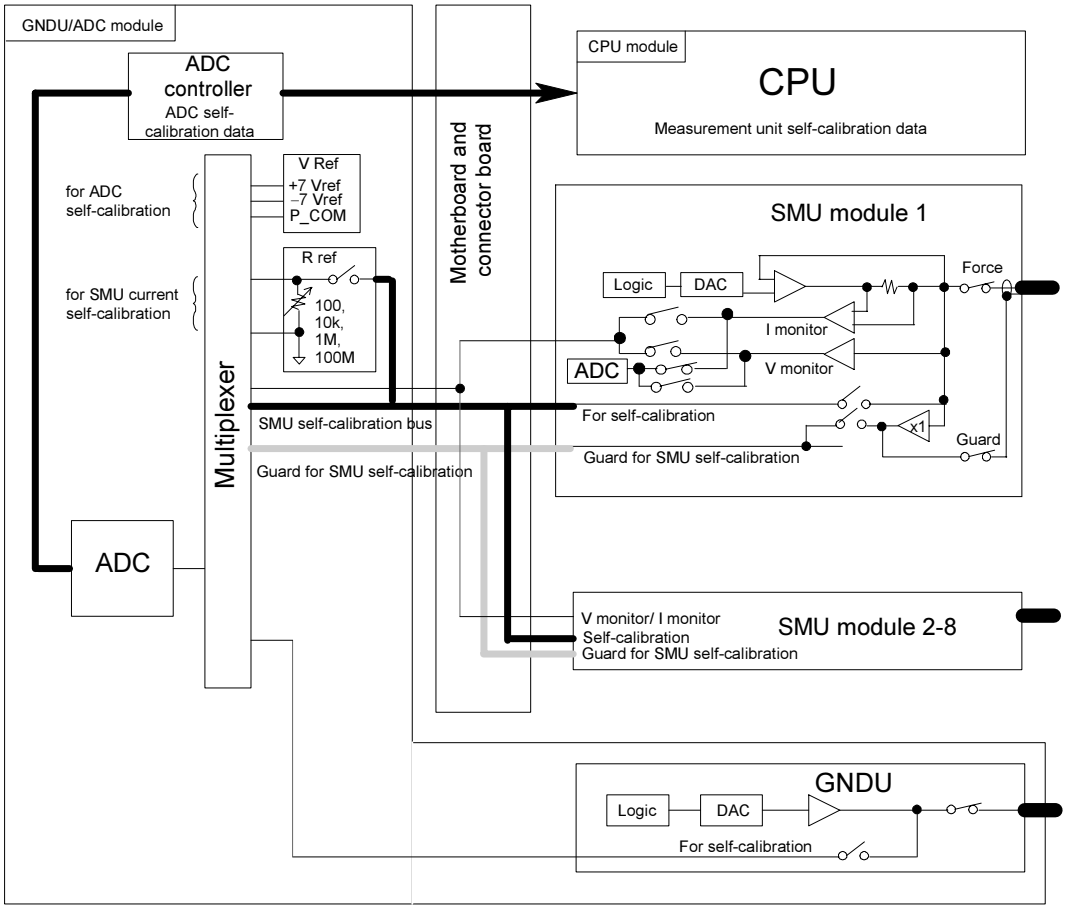
ADC self-calibration

The ADC self-calibration/self-test uses the +7 Vref, –7 Vref, and potential common.

The reference resistors are not tested.

Therefore, even if the reference resistors fail, the ADC self-calibration/self-test can be pass, and the measurement unit self-test can be fail.

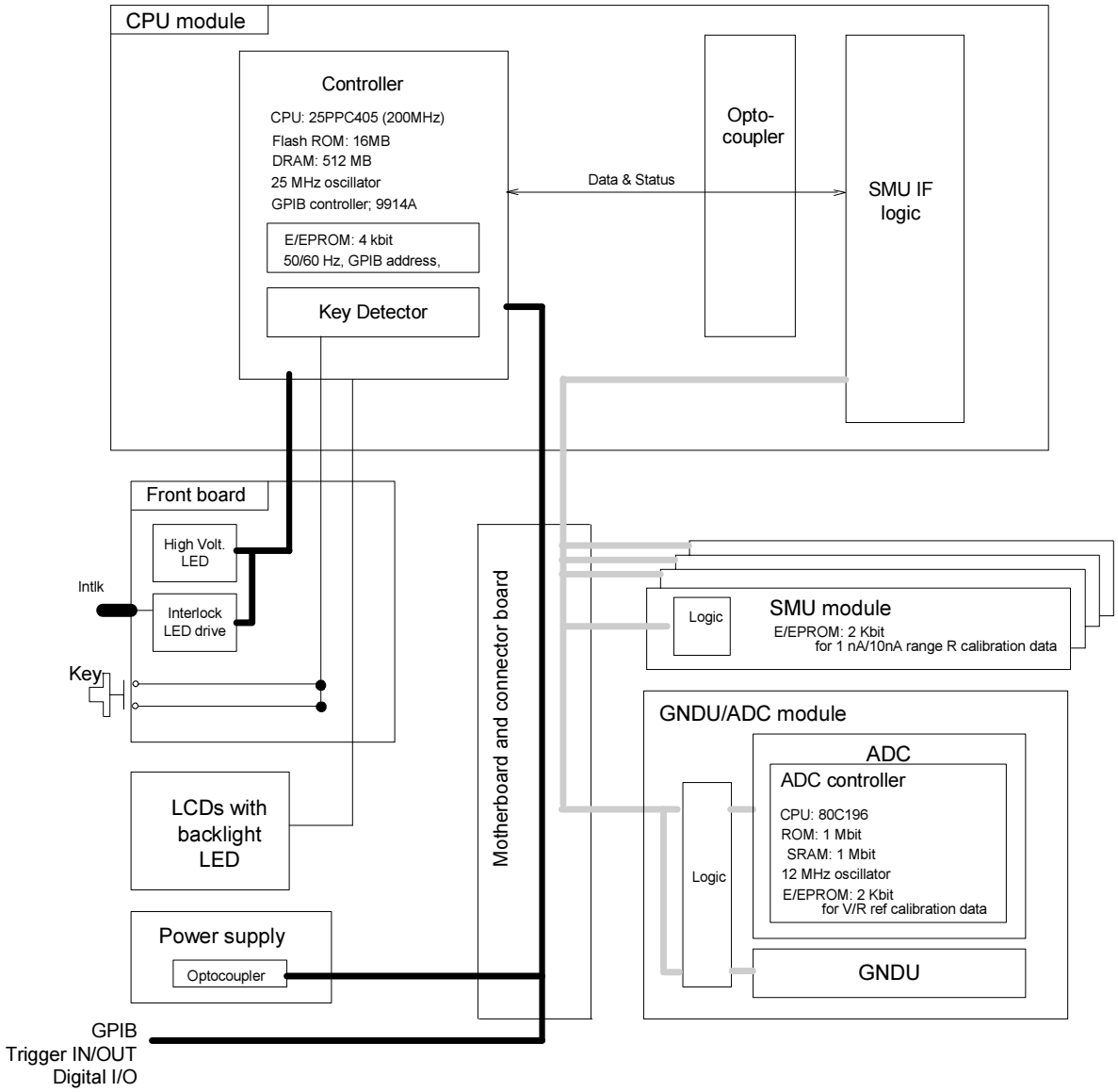
Figure 6-12 Self-calibration path (measurement bus & self-calibration bus)



CPU, GNDU/ADC Board, LCD, and Front Board

This section provides the information about CPU module, GNDU/ADC module, LCD, and front key. Figure 6-13 is the control diagram.

Figure 6-13 Agilent E5270A/E5272A/E5273A control diagram



CPU module

The controller controls the front panel (including keys and LEDs), LCD, GPIB, digital I/O, trigger in/out, and interlock (Intlk), GNDU/ADC module, SMUs. CPU module consists of the host controller and the SMU interface logic.

GNDU/ADC module

The GNDU/ADC module consists of the ADC, voltage and resistance references, ADC controller, and EEPROM.

ADC	The ADC is used for high-resolution measurement.
V/R references	The voltage references are used as the reference voltage. The resistance references are used for the calibration and diagnostics of the SMU.
ADC controller	The ADC controller performs the analog to digital conversion control (such as the integration time setting), sampling interval control, ADC self-calibration/self-test, and calculation of the ADC correction value.
EEPROM	The EEPROM on the ADC module stores the calibration data of voltage and resistance references, which are measured by the external calibration.

LCD

The LCD is a two-line, 40-character monochrome display with backlight LEDs.

Front board

The front key input is detected as follows:

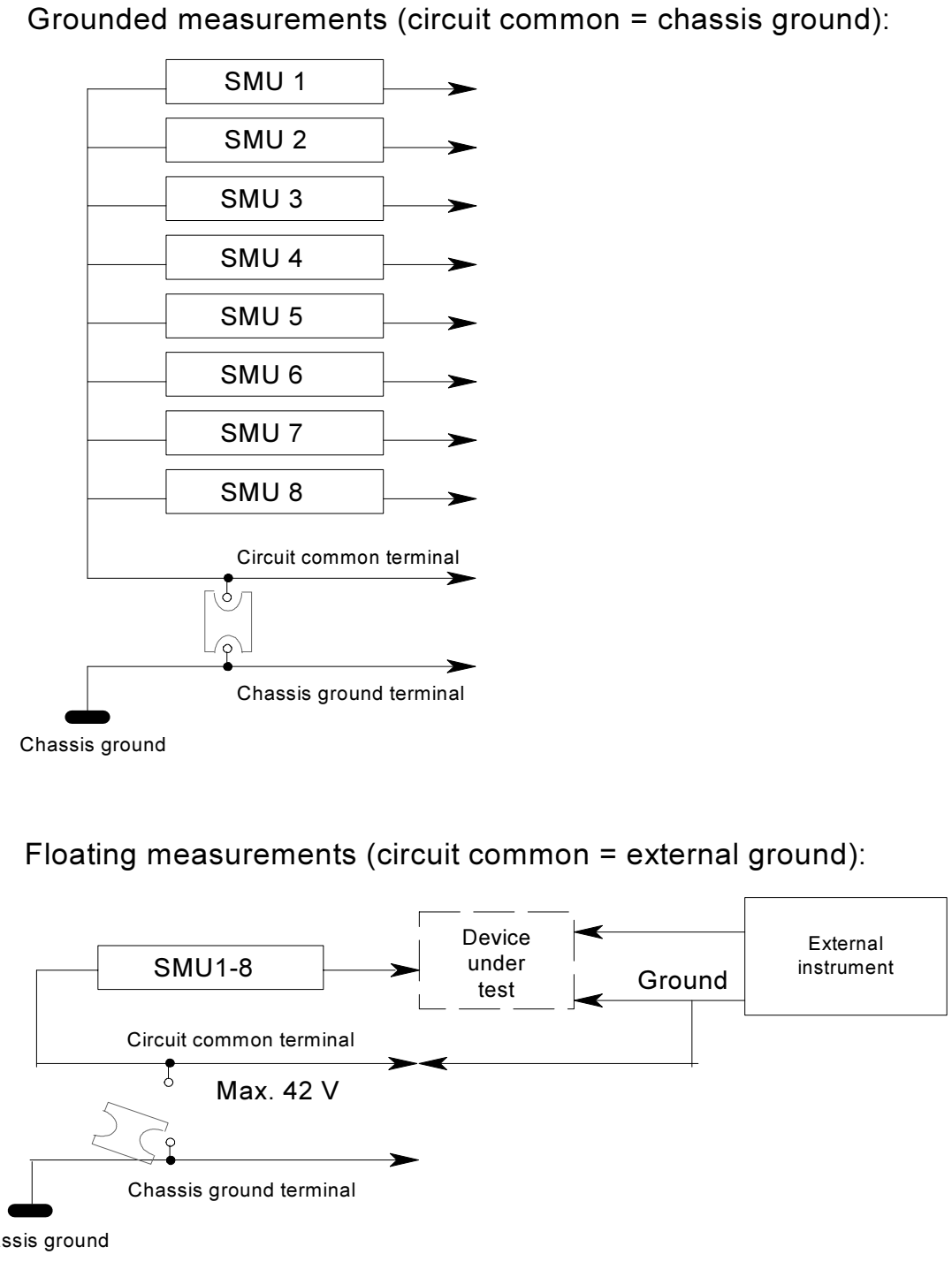
1. Each front rubber key has a carbon pad behind the key, which is an electrical conductor. If a key is pressed, two points on the front board are closed.
2. The closed points are detected by the key decoder on the CPU board.

Circuit common and chassis ground

The circuit common and chassis ground terminals on the front panel are used during floating or grounded measurements. When the test device is grounded by an external instrument (wafer-prober or external sources, etc.), use the floating measurements to prevent noise from ground loops. The E5270A/E5272A/E5273A forces and measures voltage or current referenced to external ground (±42 V maximum). If the external ground is greater than ±42 V referenced to chassis ground, the E5270A/E5272A/E5273A might be damaged as a consequence. Note that the voltage appears on the outer conductor of the force terminals, which are the circuit common.

When you do not perform the floating measurements, connect the chassis ground and circuit common with the shorting-bar for noise reduction and safety.

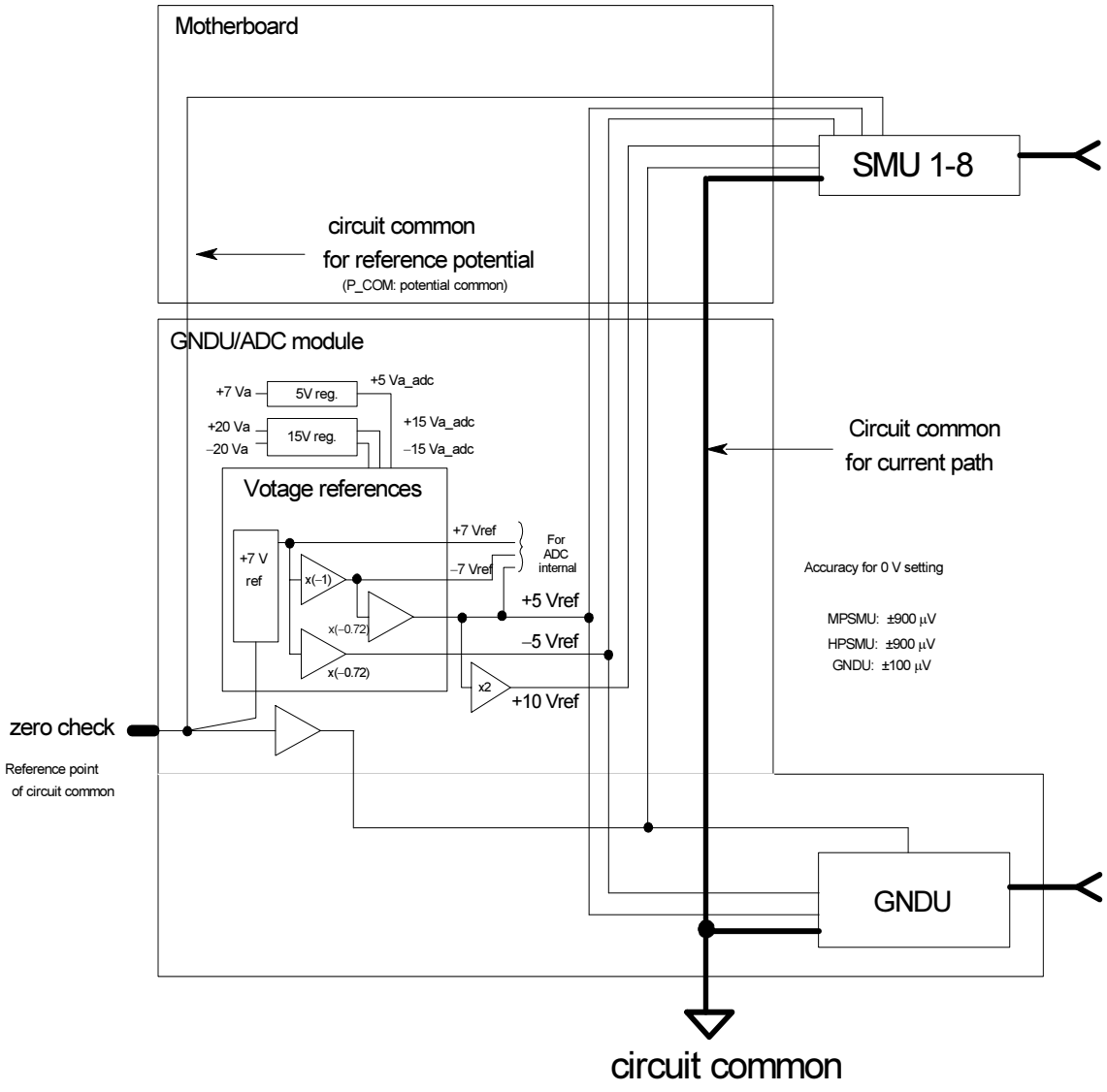
Figure 6-14 Circuit common and chassis ground terminals



Voltage references and zero check terminal

This section provides the destination of the zero check terminal and voltage references on the ADC board. Figure 6-15 is a simplified circuit diagram of the zero check terminal and voltage references.

Figure 6-15 Voltage reference and zero check terminal



Zero check terminal

The zero check terminal is the reference point/potential of the circuit common. Therefore, it is the reference potential of the E5270A/E5272A/E5273A. The specification of voltage output/measurement accuracy is defined in reference to this point.

For example, 0 V output accuracies are:

MPSMU: ±900 μV

HPSMU: ±900 μV

GNDU: ±100 μV

Because the referential potential of the circuit common is separated from the current path of the circuit common, the potential difference does not occur in all the measurement units.

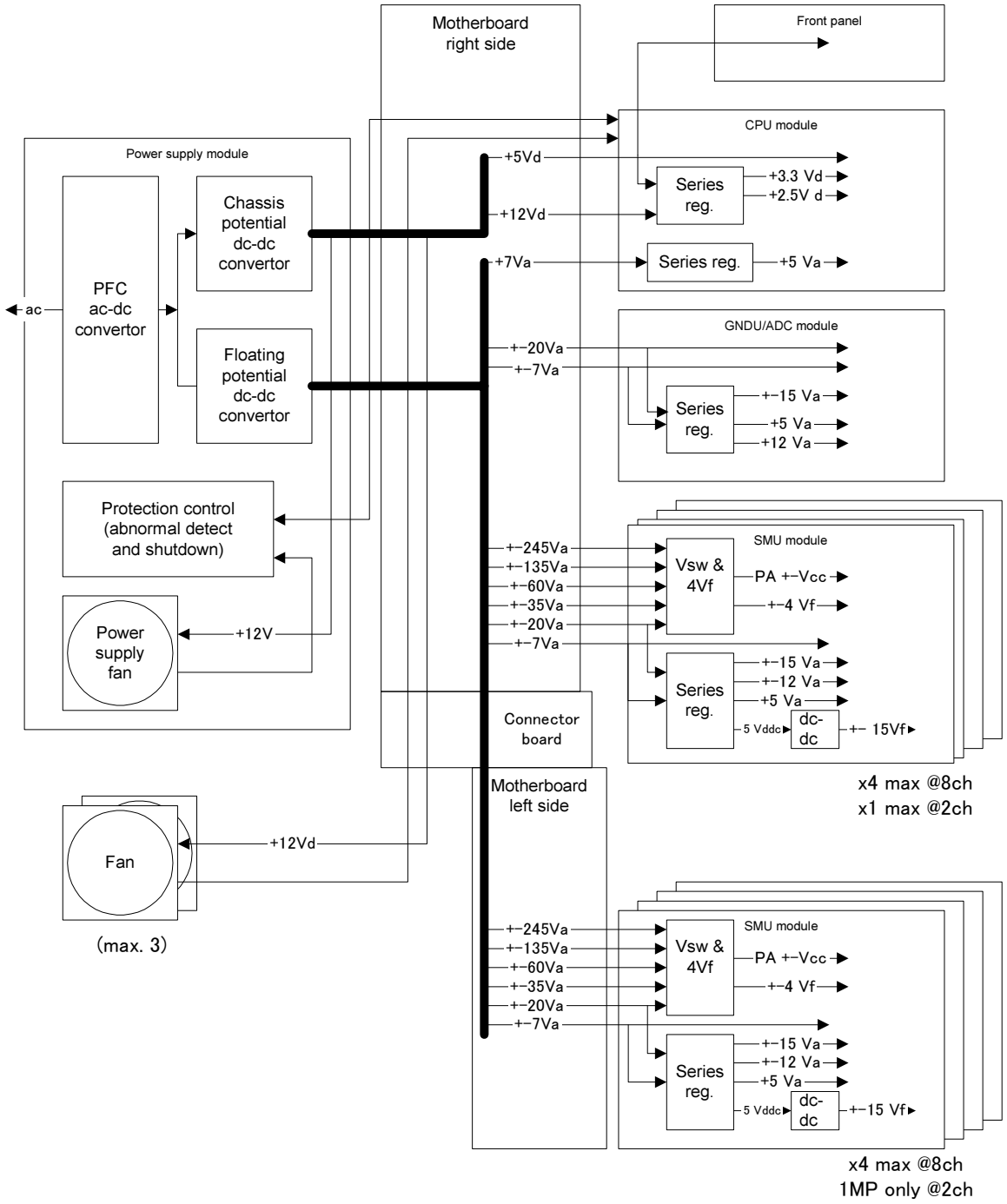
Voltage references

The reference voltages are supplied from the voltage regulator on the GNDU/ADC module. The high resolution ADC uses +7 Vref, –7 Vref, +5 Vref, and potential common (zero check) as the reference voltages. The measurement units use +5 Vref, –5 Vref, +10 Vref, and potential common (zero check) as the reference voltages. (high-speed ADC on each SMU uses +10 Vref.)

Power Supply

This section provides information about the power supply destination for each dc voltage in E5270A/E5272A/E5273A. Figure 6-16 is the mainframe block diagram for the power supply destination.

Figure 6-16 Power supply destination



dc voltages on the power supply module

Table 6-1 and 6-2 list dc voltages, which are forced from the power supply module, and the specifications. (Table 6-1 is for the power supply module of E5270A and Table 6-2 is for E5272A and E5273A. Table 6-3 and figure 6-17 show the dc output voltage on the power supply module connectors and pin location of the connector.

Table 6-1 Agilent E5270A power supply output voltages and protection circuit

Signal	Output voltage	Current	Common	Built-in protection circuit		
				Over current	Over voltage	Under voltage
+5 Vd	+5.1 Vdc ± 3% (4.947 to 5.253 V)	0.1 to 3.5 A	Chassis	4.4 ± 0.5 A	6.0 ± 0.5 V	4.1 ± 0.4 V
+12 Vd	+12 Vdc ± 10% (10.8 to 13.2 V)	0.3 to 0.8 A	Chassis	1.0 ± 0.1 A	15 ± 1 V	9 ± 0.7 V
+7 Va	+7 Vdc ± 12% (6.16 to 7.84 V)	0.1 to 8 A	Circuit	9.8 ± 0.7 A	9.0 ± 0.7 V	5.3 ± 0.5 V
−7 Va	−7 Vdc ± 12% (− 6.16 to −7.84 V)	0.1 to 7 A	Circuit	−8.7 ± 0.9 A	−9.0 ± 0.7 V	−5.3 ± 0.5 V
+20 Va	+20 Vdc ± 10% (18 to 22 V)	0.1 to 5.5 A	Circuit	6.5 ± 0.65 A	26 ± 2 V	15 ± 1.5 V
−20 Va	−20 Vdc ± 10% (−18 to −22 V)	0.1 to 5.5 A	Circuit	−6.5 ± 0.65 A	−26 ± 2 V	−15 ± 1.5 V
+35 Va	+34 Vdc ± 8% (31.28 to 36.72 V)	0 to 4.1 A	Circuit	5.2 ± 0.53 A	42 ± 3 V	26 ± 2 V
−35 Va	−34 Vdc ± 8% (−31.28 to −36.72 V)	0 to 4.1 A	Circuit	5.2 ± 0.53 A	42 ± 3 V	−26 ± 2 V
+60 Va	+56 Vdc ± 10% (−50.4 to − 61.8 V)	0 to 2.1 A	Circuit	3.15 ± 0.75 A	71 ± 6 V	43 ± 4 V
−60 Va	−56 Vdc ± 10% (−50.4 to −61.8 V)	0 to 2.1 A	Circuit	3.15 ± 0.75 A	−71 ± 6 V	−43 ± 4 V
+135 Va	+134 Vdc ± 10% (120.6 to 147.4 V)	0 to 0.6 A	Circuit	1.02 ± 0.26 A	170 ± 13 V	103 ± 8 V
−135 Va	−134 Vdc ± 10% (−120.6 to −147.4 V)	0 to 0.6 A	Circuit	1.02 ± 0.26 A	−170 ± 13 V	−103 ± 8 V
+245 Va	+245 Vdc ± 10% (220.5 to 269.5 V)	0 to 0.3 A	Circuit	0.46 ± 0.11 A	290 ± 9 V	188 ± 14 V
−245 Va	−245 Vdc ± 10% (−220.5 to −269.5 V)	0 to 0.3 A	Circuit	0.46 ± 0.11 A	−290 ± 9 V	−188 ± 14 V

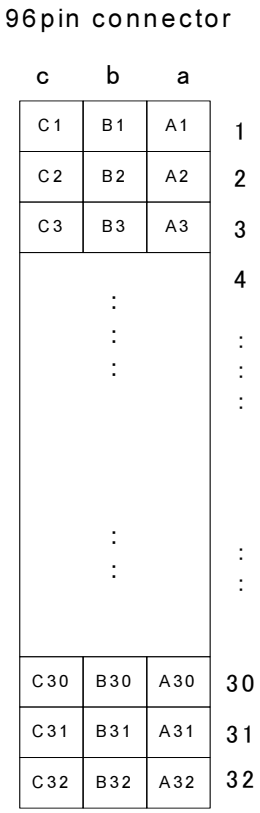
Table 6-2 Agilent E5272A/E5273A power supply output voltages and protection circuit

Signal	Output voltage	Current	Common	Built-in protection circuit		
				Over current	Over voltage	Under voltage
+5 Vd	+5.1 Vdc ± 3% (4.947 to 5.253 V)	0.1 to 3.5 A	Chassis	4.4 ± 0.5 A	6.0 ± 0.5 V	4.1 ± 0.4 V
+12 Vd	+12 Vdc ± 10% (10.8 to 13.2 V)	0.3 to 0.8 A	Chassis	1.0 ± 0.1 A	15 ± 1 V	9 ± 0.7 V
+7 Va	+7 Vdc ± 12% (6.16 to 7.84 V)	0.1 to 4.3 A	Circuit	5.3 ± 0.6 A	9.0 ± 0.7 V	5.3 ± 0.5 V
–7 Va	–7 Vdc ± 12% (– 6.16 to –7.84 V)	0.1 to 3.5 A	Circuit	4.3 ± 0.5 A	–9.0 ± 0.7 V	–5.3 ± 0.5 V
+20 Va	+20 Vdc ± 10% (18 to 22 V)	0.1 to 3.0 A	Circuit	3.8 ± 0.4 A	26 ± 2 V	15 ± 1.5 V
–20 Va	–0 Vdc ± 10% (–18 to –22 V)	0.1 to 3.0 A	Circuit	3.8 ± 0.4 A	–26 ± 2 V	–15 ± 1.5 V
+35 Va	+34 Vdc ± 8% (31.28 to 36.72 V)	0 to 2.5 A	Circuit	3.2 ± 0.4 A	42 ± 3 V	26 ± 2 V
–35 Va	–34 Vdc ± 8% (–31.28 to –36.72 V)	0 to 2.5 A	Circuit	3.2 ± 0.4 A	42 ± 3 V	–26 ± 2 V
+60 Va	+56 Vdc ± 10% (–50.4 to – 61.8 V)	0 to 0.6 A	Circuit	1.15 ± 0.3 A	71 ± 6 V	43 ± 4 V
–-60 Va	–56Vdc ± 10% (–50.4 to –61.8 V)	0 to 0.6 A	Circuit	1.15 ± 0.3 A	–71 ± 6 V	–43 ± 4 V
+135 Va	+134 Vdc ± 10% (120.6 to 147.4 V)	0 to 0.22 A	Circuit	0.38 ± 0.1 A	170 ± 13 V	103 ± 8 V
–135 Va	–134 Vdc ± 10% (–120.6 to –147.4 V)	0 to 0.22 A	Circuit	0.38 ± 0.1 A	–170 ± 13 V	–103 ± 8 V
+245 Va	+245 Vdc ± 10% (220.5 to 269.5 V)	0 to 0.08 A	Circuit	0.14 ± 0.04 A	290 ± 9 V	188 ± 14 V
–245 Va	–245 Vdc ± 10% (–220.5 to –269.5 V)	0 to 0.08 A	Circuit	0.14 ± 0.04 A	–290 ± 9 V	–188 ± 14 V

Table 6-3 Agilent E5270A/E5272A/E5273A power supply pin assignment

Connector	Pin number	Signal
96-pin connector	A1, B1, C1	Circuit common
	A2, B2, C2	+60 Va
	A3, B3, C3	+135 Va
	A4, B4, C4	+245 Va
	A5, B5, C5	+35 Va
	A6, B6, C6	+35 Va
	A7, B7, C7	–35 Va
	A8, B8, C8	–35 Va
	A9, B9, C9	–245 Va
	A10, B10, C10	–135 Va
	A11, B11, C11	–60 Va
	A12, B12, C12	Circuit common
	A13, B13, C13	Circuit common
	A14, B14, C14	Circuit common
	A15, B15, C15	Circuit common
	A16, B16, C16	+20 Va
	A17, B17, C17	+20 Va
	A18, B18, C18	–20 Va
	A19, B19, C19	–20 Va
	A20, B20, C20	+7 Va
	A21, B21, C21	+7 Va
	A22, B22, C22	+7 Va
	A23, B23, C23	–7 Va
	A24, B24, C24	–7 Va
	A25, B25, C25	–7 Va
	A26, B26, C26	Circuit common
	A27, B27, C27	Digital common
	A28, B28, C28	Digital common
	A29, B29, C29	Not a power supply pin
	A30, B30, C30	+5 Vd
	A31, B31, C31	+5 Vd
	A32	+12 Vd
	B32, C32	Digital common

Figure 6-17 Agilent E5270A/E5272A/E5273A power supply pin location (cable end)



dc voltages on CPU, GNDU/ADC, and SMU modules

The post regulator filters and regulates some outputs of (switching regulator) power supply again.

- CPU module

+3.3 Vd, +2.5 Vd For controller

+5 Va For SMU interface logic.

- GNDU/ADC module

±15 Va For analog circuits.

+12 Va For relay drive.

+5 Va For GNDU/ADC controller logic.

- SMU module

±15 Va For analog circuits.

±15 Va For analog and relay drive.

+5Va For logic circuits.

±15 Va For SMU floating circuits.

Fuses

There are no replaceable fuses.

Abnormal Condition Detectors

Power supply ac input Monitor

If the ac line voltage drops to 80 Vac, the E5270A/E5272A/E5273A power supplies automatically turn off. If the voltage recovers and exceeds 80 Vac, the E5270A/E5272A/E5273A automatically turns on again.

If this occurs, monitor the ac line first. Usually, this means the supplying ac line is abnormal. For example, momentary power loss occurs, or voltage sags occur, or the tops of ac line waveform are clipped. The sags and clipped tops tend to occur when the power used exceeds the supply capability of the ac line.

Power supply over V, over I, under V, and fan stop detectors

If the power supply detects an overvoltage, overcurrent, undervoltage, or its fan stop, the power supply automatically shuts down by the emergency shutdown function.

To recover this, you have to set the LINE switch off, then back on.

The following is the shutdown sequence.

1. Detector notifies the CPU within 15 milliseconds after the detection.
2. The power supply starts turning off. The outputs can be kept at least three milliseconds after CPU notification.
3. The CPU sets all source unit outputs (DACs) to 0 V, and all source unit output switches to OFF. This step cannot always be performed because the power shutdown has already started. When source units are set to 0 V, the order is from higher voltage to lower voltage units.

Measurement unit over V/I detectors

If the SMU detects an overvoltage or overcurrent:

1. The detector notifies the CPU.
2. The CPU starts to set all source unit outputs (DACs) to 0 V, and all source unit output switches to OFF.
3. Then CPU waits for 15 milliseconds.
4. If the abnormal voltage or current is corrected, only an error message displayed, and the shutdown does not occur. If not corrected, the CPU turns the power supply OFF by the emergency shutdown function.

Table 6-4 Measurement unit detectors for protection

Unit	Over Voltage Detector	Over Current Detector
MPSMU	Y (±120 V on force)	–
HPSMU	–	Y[a]

a. See the following table.

Table 6-5 HPSMU overcurrent detector detection value

Voltage range (range max. current)	Current output or measurement range	Detection value
2 V, 20 V (1 A)	100 mA, 1 A	None
	≤ 10 mA	70 mA
40 V (500 mA)	100 mA, 1 A	650 mA
	≤ 10 mA	70 mA
100 V (125 mA)	100 mA, 1 A	170 mA
	≤ 10 mA	70 mA
200 V (50 mA)	All	75 mA

Emergency shutdown function

If either of the following occurs, the E5270A/E5272A/E5273A automatically shuts down to prevent damage (power is off, but LINE switch stays in ON position).

- When the power supply detects an abnormal condition. (except detection by the ac input monitor).
- When the measurement unit detects an overvoltage or overcurrent, and the abnormal condition is not corrected even if the output switches of all measurement units are set to off.
- When the power supply detects the power supply fan slow down or stop.
- When the CPU module detects the frame fan slow down or stop.

In this case, the power supply is locked into the power-off setting. To turn it back on, do as follows:

1. Set the LINE switch to OFF once.
2. Wait for 10 seconds or more.
3. Set the LINE switch to ON.

If the AC Line Monitor detects an abnormal condition, the power supply is turned off, but is not locked into the power-off setting. Therefore, if the abnormal condition is corrected, the power supply (that is, E5270A/E5272A/E5273A) automatically boots up.

Causes

An abnormal voltage or current on internal circuits can be caused by:

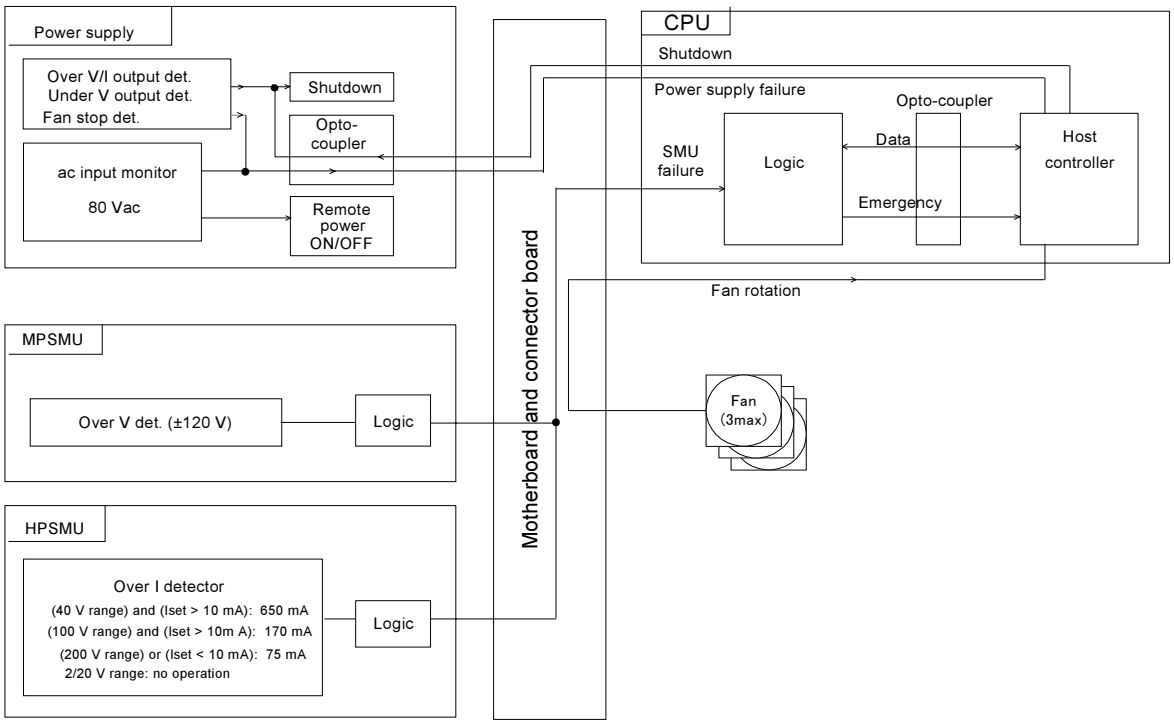
- incorrect connection between the instrument and test devices
- overvoltage or overcurrent input.
- shorting between an SMU guard output and another guard or output
- ac LINE having an abnormal voltage, impulses, surges
- hardware failure

NOTE

❑ An ADC failure can cause over voltages in the HPSMU/MPSMU.

For example, if the ADC module is not connected to the motherboard, the E5270A/E5272A/E5273A shuts down by overvoltage of the measurement units. This is because the measurement unit loses the voltage reference, and the amplifiers are saturated.

Figure 6-18 Agilent E5270A/E5272A/E5273A abnormal condition detectors



External Instrument Control

The E5270A/E5272A/E5273A has some interfaces to control and communicate with an external instrument. This section provides the information for the following interfaces.

- “Digital I/O”
- “Interlock”

Digital I/O

The digital I/O is for connecting other instruments. The digital I/O has an open collector with 1kohm pull up resistor and 100 ohm series resistor. See Figure 6-19 for the block diagram. And Figure 6-20 and table 6-6 show the digital I/O pin assignment.

Figure 6-19 Digital I/O block diagram

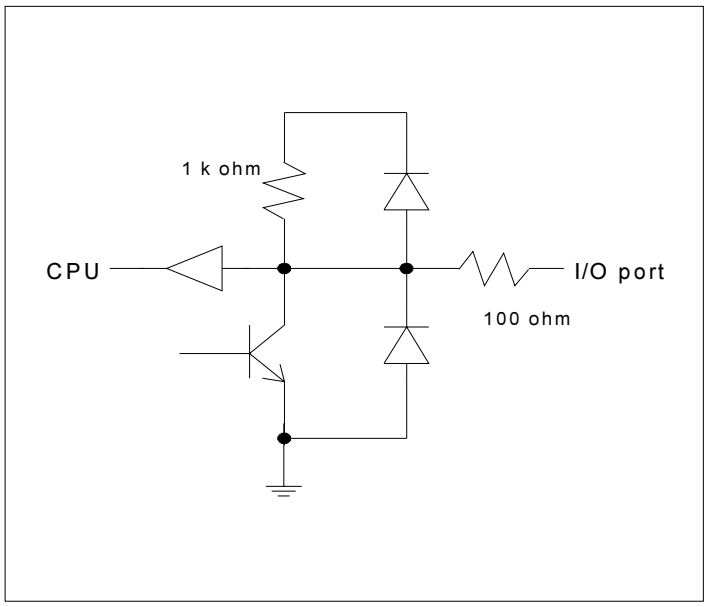


Figure 6-20 Digital I/O (25-Pin) connector pins

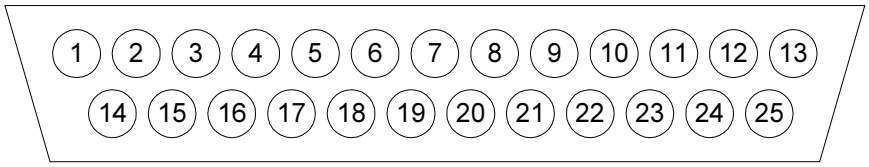


Table 6-6 Digital I/O (25-Pin) pin assignment

Pin number	Signal (direction)	Pin number	Signal (direction)
1	No connection	14	No connection
2	No connection	15	Digital I/O - 00
3	Digital I/O - 01	16	Digital I/O - 02
4	Digital I/O - 03	17	Digital I/O - 04
5	Digital I/O - 05	18	Digital I/O - 06
6	Digital I/O - 07	19	Digital I/O - 08
7	Digital I/O - 09	20	Digital I/O - 10
8	Digital I/O - 11	21	Digital I/O - 12
9	Digital I/O - 13	22	Digital I/O - 14
10	Digital I/O - 15	23	Do not connect
11	Do not connect	24	Do not connect
12	Do not connect	25	Ground
13	Ground		

NOTE Do not connect and use the pins 11, 12, 23, and 24. They are used as hardware development purposes.

Interlock

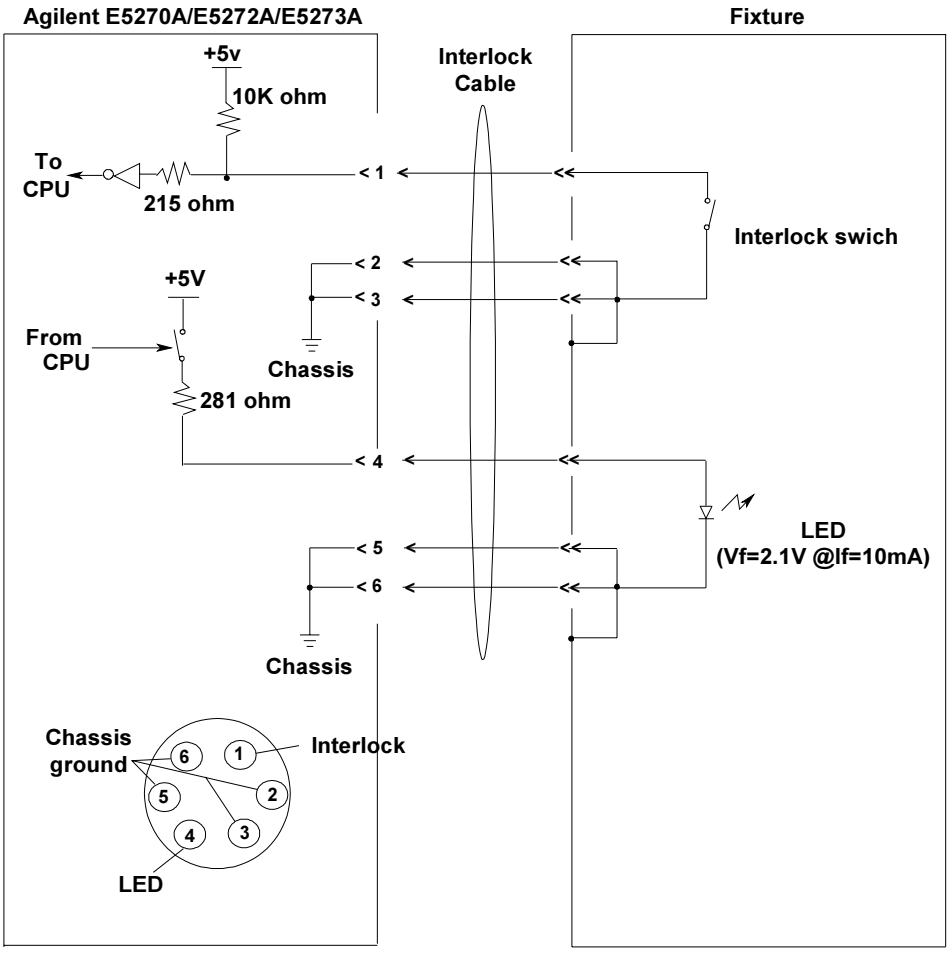
The interlock circuit is designed to prevent electrical shock when a user touches the measurement terminals. If the interlock pin 1 and chassis ground are not closed, the SMU output is limited, and the SMU can force a maximum 42 V. The following is information on each pin of the interlock connector, and figure 6-21 is the block diagram of the interlock and fixture.

pin 1 — The pin 1 is the interlock line. When the line is set to low (closed to chassis ground), E5270A/E5272A/E5273A can force a voltage greater than 42 V. If no voltage is applied to the interlock line, the interlock line is +5 V (serial resistance is 10 kohm), and E5270A/E5272A/E5273Acannot force high voltages (greater than 42 V). In the 16442B test fixture, the interlock switch (interlock line) synchronizes with the fixture cover. When the fixture cover opens, the interlock switch also opens, and E5270A/E5272A/E5273A cannot force high voltage. When the fixture cover closes, the interlock switch also closes, and E5270A/E5272A/E5273A can force high voltage.

pin 4 — The pin 4 is external LED drive line. When the interlock line is shorted to ground, the external LED drive line is +5 V. The 16442B test fixture uses this line for the fixture LED.

pins 2, 3, 5, and 6 — The pin 2, 3, 5, and 6 are chassis ground, and used for connecting the pin 1 (interlock line) and pin 4 (LED drive line) to the ground.

Figure 6-21 Interlock block diagram



A Error Message

If Agilent E5270 series are not operated correctly, or if self-test/calibration fails, error codes and error messages are displayed. This chapter lists error codes and messages of the Agilent E5270.

This chapter consists of the following sections:

- “Self-Test/Calibration Error”
- “Operation Error”
- “Channel Status Code”

Self-Test/Calibration Error

When the Agilent E5270 fails the self-test or self-calibration, the Agilent E5270 returns the following error code and error message.

CPU test

700	CPU failed NVRAM read/write test.
701	CPU failed FPGA read/write test.
702	CPU failed H-RESOLN ADC end signal test.
703	CPU failed H-RESOLN ADC start signal test.
704	CPU failed emergency status signal test.
705	CPU failed SRQ status signal test.
706	CPU failed high voltage status signal test.
707	CPU failed low voltage status signal test.
708	CPU failed DAC settling status signal test.
709	CPU failed measure ready status signal test.
710	CPU failed set ready status signal test.
711	CPU failed measure end status signal test.
712	CPU failed measure trigger signal test.
713	CPU failed pulse trigger signal test.
714	CPU failed abort trigger signal test.
715	CPU failed DAC set trigger signal test.
716	CPU failed LCD read/write test.

GNDU/ADC test

720	H-RESOLN ADC is not installed.
721	H-RESOLN ADC failed ROM/RAM test.
722	H-RESOLN ADC failed B-COM offset DAC test.
723	H-RESOLN ADC failed sampling ADC test.
724	H-RESOLN ADC failed integrating ADC test.
725	H-RESOLN ADC failed bus function test.
740	GNDU failed calibration.

SMU test

In the error code, N indicates the slot number. If the module is installed in slot 1, and it fails the function test, the error code will be 1760.

N760	SMU failed function test.
N761	SMU failed VF/VM function test.
N762	SMU failed IF/IM function test.
N763	SMU failed loop status test.
N764	SMU failed temperature sensor test.
N765	SMU failed CMR amplifier calibration.
N766	SMU failed CMR amplifier adjustment.
N767	SMU failed CMR 100 V range full output test.
N768	SMU failed VF/VM calibration.
N769	SMU failed VM offset calibration.
N770	SMU failed VM gain calibration.
N771	SMU failed VF offset calibration.
N772	SMU failed VF gain calibration.
N773	SMU failed VF gain calibration at 20 V range.
N774	SMU failed VF filter offset calibration.
N775	SMU failed H-SPEED ADC self-calibration.
N776	SMU failed H-SPEED ADC VM offset calibration.
N777	SMU failed H-SPEED ADC VM gain calibration.
N778	SMU failed IF/IM calibration.
N779	SMU failed calibration bus test.
N780	SMU failed IM offset calibration.
N781	SMU failed IM gain calibration.
N782	SMU failed IF offset calibration.
N783	SMU failed IF gain calibration.
N784	SMU failed IDAC filter offset calibration.
N785	SMU failed oscillation detector test.
N786	SMU failed I bias test.
N787	SMU failed common mode rejection test.
N789	SMU failed high voltage detector test.
N790	SMU failed zero voltage detector test.
N791	SMU failed V hold test.
N792	SMU failed V switch test.

Operation Error

The following are the error codes and their messages that may occur when you operate the E5270 series.

100	Undefined GPIB command.
	Send the correct command.
102	Incorrect numeric data syntax.
	Correct the data syntax.
103	Incorrect terminator position.
	Correct the command syntax. The number of parameters will be incorrect.
120	Incorrect parameter value.
	Correct the parameter value.
121	Channel number must be 1 to 2, or 1 to 8.
	Correct the channel number. The channel number must be 1 to 2 for the Agilent E5272A/E5273A, or 1 to 8 for the Agilent E5270A.
122	Number of channels must be corrected.
	Check the MM, FL, CN, CL, IN, DZ, or RZ command, and correct the number of channels.
123	Compliance must be set correctly.
	Incorrect compliance value was set. Set the compliance value correctly.
124	Incorrect range value for this channel.
	Check the range value available for the channel, and correct the range value.
126	Pulse base and peak must be same polarity.
	The polarity of the base and peak values must be the same in the PI command. Also the polarity of the base, start, and stop values must be the same in the PWI command.
130	Start and stop must be same polarity.
	For a log sweep, the polarity of the start and stop values must be the same in the WV, WI, WSV, WSI, or WNX command. Also, 0 is not allowed for the start and stop values.
150	Command input buffer is full.
	The Agilent E5270 can receive 256 characters maximum including the terminator at one time.
152	Cannot use failed module.
	The channel number specifying the module failed the self-test or calibration. Specify another module that passed the self-test or calibration. For the service purpose, execute the RCV command to enable the module.
153	No module for the specified channel.
	Module is not installed in the slot specified by the channel number.

160 Incorrect ST execution.

The internal memory programming can be started by the ST command and completed by the END command. Do not enter the ST command between the ST command and the END command.

161 Incorrect END execution.

The internal memory programming can be started by the ST command and completed by the END command. Do not send the END command before starting the programming.

162 Incorrect command for program memory.

Specified command cannot be stored in the program memory. For the incorrect commands, see chapter 2 of *Programming Guide*.

170 Incorrect usage of internal variable.

The internal variable must be %I*n* for integer data, or %R*n* for real data. where *n* is an integer, 0 to 99. Use %I*n* for the integer type command parameters; and use %R*n* for the real type command parameters. For the internal variables, see chapter 4 of Programming Guide.

171 Internal variable is not allowed.

The internal variables %I*n* and %R*n* are not available for the ACH, VAR, and VAR? commands. Do not use the internal variables for the commands.

200 Channel output switch must be ON.

To enter the specified command, set the channel output switch to ON.

201 Compliance must be set.

To change the source output mode (voltage or current), set the compliance value.

202 Interlock circuit must be closed.

To set the output voltage or the voltage compliance to more than ±42 V (high voltage state), close the interlock circuit. If the interlock circuit is opened in the high voltage state, outputs of all units will be set to 0 V.

203 Cannot enable channel.

The channel output switch cannot be set to ON in the high voltage state. Set the output voltage or the voltage compliance to ±42 V or less to set the switch to ON.

204 Cannot disable channel.

The channel output switch cannot be set to OFF in the high voltage state. Set the output voltage or the voltage compliance to ±42 V or less to set the switch to OFF. Or send the CL command with no parameter to set switches of all channels to OFF immediately.

205 DZ must be sent before RZ.

The RZ command is effective for the channels set to 0 V output by the DZ command.

206 Do not specify the channel recovered by RZ.

Specify the channels that have not been recovered yet by the RZ command after the DZ command. The RZ command cannot be executed if the specified channels include a channel that has already been recovered by the RZ command.

210 Ext trigger could not start measurement.

External trigger cannot start measurement because of busy condition.

211 TM1 must be sent to use GET.

Send the TM1 command to use the GPIB GET command (TRIGGER statement in HP BASIC).

212 Compliance must be set correctly.

Compliance was not set or an incorrect compliance value was set in the DV, DI, PV, PI, PWV, PWI, TDV, TDI, LSV, LSI, LSSV, LSSI, BSV, BSI, BSSV, or BSSI command. Set the compliance value correctly.

213 Cannot perform self-test or calibration.

Self-test and calibration cannot be performed in the high voltage state. Set the output voltage or the voltage compliance to ±42 V or less to perform the self-test or calibration.

214 Send MM before measurement trigger.

Before sending the measurement trigger, the MM command must be sent to set the measurement mode.

220 Send WV or WI to set primary sweep source.

Before triggering the staircase sweep measurement, triggering the staircase sweep with pulsed bias measurement, or sending the WSV, WSI, or WNX command to set the synchronous sweep source, send the WV or WI command to set the primary sweep source.

221 Send PWV or PWI to set pulse sweep source.

Before triggering the pulsed sweep measurement, or sending the WSV or WSI command to set the synchronous sweep source, send the PWV or PWI command to set the pulse sweep source.

222 Send PV or PI to set pulse source.

Before triggering the staircase sweep with pulsed bias measurement, send the PV or PI command to set the pulse source.

223 Compliance must be set correctly.

Compliance was not set or an incorrect compliance value was set in the WV, WI, WSV, WSI, WNX, or BDV command. Set the compliance value correctly.

224 Sweep and sync output modes must be the same.

The primary sweep channel and the synchronous sweep channel must be different, and they must be set to the same output mode (voltage or current).

225 Send WSV, WSI, or WNX to get sync sweep data.

If you enable data output of the synchronous sweep source, do not forget to set the synchronous sweep source by the WSV, WSI, or WNX command. For data output, see chapter 4 of *Programming Guide*.

226 Set linear sweep for MM4 or MM5.

Only the linear sweep is available for the PWV or PWI command for the pulsed sweep measurement (MM4) or the WV or WI command for the staircase sweep with pulsed bias measurement (MM5).

227 Sweep measurement was aborted.

Sweep measurement was aborted by the automatic sweep abort function or the power compliance.

230 Pulse source must be set.

To perform the pulsed spot measurement (MM3), send the PV or PI command to set the pulse source.

231 Compliance must be set correctly.

Compliance was not set or an incorrect compliance value was set in the PV, PI, PWV, or PWI command. Set the correct compliance value effective for the pulse output.

238 Too large pulse width (max. 2 s).

The maximum value of the pulse width is 2 s. And the available value depends on the pulse period value. See chapter 4 of *Programming Guide*.

239 Pulse width must be 0.5 ms or more.

Set the pulse width to 0.5 ms or more. See chapter 4 of *Programming Guide*.

253 Program memory is full.

Maximum of 2000 programs or 40000 commands can be stored in the program memory. See chapter 4 of *Programming Guide*.

254 Invalid input for a memory program.

The GPIB GET command (TRIGGER statement in HP BASIC) and an external trigger input are not allowed in a memory program (between the ST and END commands).

255 Maximum nesting level is eight.

Nesting (one program calling another) of a memory program must be eight levels or less.

260 Data output buffer is full.

Maximum 34034 measurement data items can be stored in the data output buffer.

270 Search source channel must be set.

Before triggering the search measurement or sending the LSSV, LSSI, BSSV, or BSSI command to set the synchronous search source, send the LSV, LSI, BSV, or BSI command to set the primary search source.

271 Search monitor channel must be set.

Before triggering the search measurement, send the LGV, LGI, BGV, or BGI command to set the search monitor channel.

273 Search and sync output modes must be the same.

The primary search source channel and the synchronous source channel must be different, and they must be set to the same output mode (voltage or current).

275 Search target must be compliance value or less.

The search target value must be less than or equal to the compliance value of the search monitor channel. Correct the search target value or the compliance value.

276 Start and stop must be different.

Set different values for the search start and stop values.

277 Step must be output resolution or more.

Set the search step value to the output resolution or more.

278 Search and sync channels must be different.

Set the search source and the synchronous source to different channels.

279 Search monitor mode must be compliance side.

Send the LGI/BGI command to set the voltage source search monitor channel, or send the LGV/BGV command to set the current source search monitor channel.

303 Excess voltage in MPSMU.

Voltage that exceeds maximum voltage at the present current range was detected by a MPSMU. All output switches were set to OFF.

305 Excess current in HPSMU.

Current that exceeds maximum current at the present voltage range was detected by a HPSMU. All output switches were set to OFF.

307 Unsupported module.

This module is not supported by this firmware version. Until you update the firmware, use the Agilent E5270 with this module removed.

310 Interlock open operation error. Initialized.

Initialization was automatically performed because the E5270 failed to set its output to 0 V when the interlock circuit was opened in the high voltage condition. Any module may be defective. Perform self-test.

603 Sweep and pulse channels must be different.

Set the sweep source and the pulse source to different channels for the staircase sweep with pulsed bias measurement (MM5).

610 Quasi-pulse source channel must be set.

Before triggering the quasi-pulsed spot measurement, send the BDV command to set the quasi-pulse source.

620 TGP specified incorrect I/O port.

Specify trigger input for the Ext Trig In port, or trigger output for the Ext Trig Out port by the TGP command. See chapter 4 of *Programming Guide*.

621 Specify trigger input port for PAX/WSX.

No trigger input port was specified for the PAX or WSX command. Specify the trigger input port, or set the port as the trigger input port. See chapter 4 of *Programming Guide* to set trigger port.

622 Specify trigger output port for OSX.

No trigger output port was specified for the OSX command. Specify the trigger output port, or set the port as the trigger output port. See chapter 4 of *Programming Guide* to set trigger port.

630 Incorrect polarity of search step value.

For the linear search measurement. The step value must be positive if start<stop, or negative if start>stop.

631 Number of search steps must be 1001 or less.

For the linear search measurement. The number of search steps between start and stop must be 1001 or less. This means the |step| value must be |stop-start|/1001 or more.

632 Search measurement was aborted.

Search measurement was aborted by the automatic abort function.

640 Search limits must be range/20000 or more.

For the binary search measurement. The limit value for the search target must be *range*/20000 or more. where *range* means the measurement range actually used for the measurement.

650 Data format must be ASCII to get time data.

The time stamp function is not available for the binary data output format. To use the time stamp function, set the data output format to ASCII.

655 Cannot connect/disconnect series resistor.

The series resistor status cannot be changed in the high voltage state. Set the output voltage or the voltage compliance to ±42 V or less to connect or disconnect the series resistor.

656 Series resistor must be OFF for 1 A range.

The series resistor cannot be set to ON for the measurement channels or the output channels that use 1 A range.

Channel Status Code

The channel status code indicates the following statuses of the measurement channel, and is displayed in the channel status area on the LCD. No status code is displayed if the Agilent E5270 is in the normal condition.

X	One or more channels are oscillating.
V	Measurement data exceeds the measurement range.
C	This channel reached its compliance setting.
T	Another channel reached its compliance setting.

The status priority is:

X > V > C > T

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